ERDC/EL TR-17-14

US Army Corps
of Engineers®
Engineer Research and
Development Center

ERDC
INNOVATIVE SOLUTIONS
for a safer, better world

Wetlands Regulatory Assistance Program

Operational Draft Regional Guidebook for the Rapid Assessment of Wetlands in the North Slope Region of Alaska

Jacob F. Berkowitz, Nathan R. Beane, Kevin D. Philley,
and Matt Ferguson

August 2017

Environmental Laboratory

Wetlands Regulatory Assistance Program

ERDC/EL TR-17-14
August 2017

Operational Draft Regional Guidebook for the Rapid Assessment of Wetlands in the North Slope Region of Alaska

Jacob F. Berkowitz, Nathan R. Beane, and Kevin D. Philley

U.S. Army Engineer Research and Development Center
Environmental Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180

Matt Ferguson

U.S. Army Corps of Engineers, Alaska District
2204 3rd Street
JBER, AK 99506-0898

Final report

Approved for public release; distribution is unlimited.

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Work Unit A1210-North Slope Alaska

Abstract

This guidebook describes a rapid approach to assessing wetlands within the Arctic Foothills and Arctic Coastal Plain (North Slope) region of Alaska. This report utilized established approaches to (1) characterize regional wetlands, (2) provide the rationale used to determine assessment scores, (3) describe assessment variables utilized, (4) outline the developed assessment equations, and (5) provide a step-by-step protocol for applying results. The region's remote nature and short growing season limits the time period during which on-site data can be collected. As a result, the developed method allows for a tiered approach utilizing (1) an assessment based upon off-site data (remotely sensed or desktop resources) only or (2) an assessment using a combination of on-site (field data collection) and off-site data collection. On-site data collection may be required at the discretion of USACE. Several scenarios are presented to aid users in conducting the rapid wetland assessment.

Contents

Figures and Tables

Figures

Tables

Preface

Development of this guidebook was conducted for the Wetlands Regulatory Assistance Program under Project, A1210-North Slope Alaska. The program manager was Ms. Sally Stroupe.

The report was prepared by the Ecosystem Evaluation and Engineering Division, Wetlands and Coastal Ecology Branch, U.S. Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL). At the time of publication, Ms. Patty Tolley was Chief, CEERD-EE-W; Dr. Mark D. Farr was Chief, CEERD-EE; and Dr. Al Cofrancesco, CEERD-EM-W was the Technical Director for ERDC-EL Civil Works. The Deputy Director of ERDC-EL was Dr. Jack Davis, and the Director was Dr. Beth Fleming.

Additional preparation was provided by Mr. Calvin Alvarez, Mr. Jeremy Grauf, and Ms. Sheila Newman of the USACE, Alaska District.

COL Bryan S. Green was Commander of ERDC, and Dr. David W. Pittman was the Director.

The following people made major contributions to the development of this guidebook, including field data collection and participation in peer review: Estrella Campellone, USACE Alaska District; Gayle Martin, U.S. Environmental Protection Agency (USEPA); Louise Smith, U.S. Fish and Wildlife Service (USFWS); and Bill Streever, British Petroleum (BP) (retired). Unless otherwise indicated, all photograph credits are attributed to Dr. Nathan R. Beane.

The following provided additional technical review and comments: Dr. Tosin Sekoni, Steve Currie, and Sally Stroupe, ERDC-EL; Mary Anne Thiesing, USEPA; David V. D’Amore, U.S. Forest Service (USFS); Dr. Thomas Roberts, Tennessee Technological University; Michelle Schuman, U.S. Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS); Richard Darden, USACE Alaska District; and representatives from USACE Headquarters. Questions regarding the application of this guidebook should be directed to the

USACE Alaska District – Regulatory Division at 907-753-2712; regpagemaster@usace.army.mil.

This report should be cited as:

> Berkowitz, J. F., N. R. Beane, K. Philley, and M. W. Ferguson. 2017. *Operational draft regional guidebook for the rapid assessment of wetlands in the North Slope region of Alaska*. ERDC/EL TR-17-14. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Acronyms

ACP	Arctic Coastal Plain
ADFG	Alaska Department of Fish and Game
AF	Arctic Foothills
AGDC	Alaska Geospatial Data Clearinghouse
AVHRR	Advanced Very High Resolution Radiometer
BP	British Petroleum
CDM	Credit Debit Methodology
DEMs	Digital Elevation Models
ERDC-EL	U.S. Army Engineer Research and Development Center, Environmental Laboratory
GINA	Geographic Information Network of Alaska
GIS	Geographic Information System
HGM	Hydrogeomorphic
MLRAs	Major Land Resource Areas
NSSI	North Slope Science Initiative
USDA-NRCS	U.S. Department of Agriculture – Natural Resources Conservation Service
USDOI-BLM	U.S. Department of the Interior – Bureau of Land Management
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
V_{BG}	Bare ground

V_{DD}	Evidence of dust deposition
V_{DR}	Distance to roadway
V_{IH}	Impediment to hydrology
V_{IW}	Impediment to wildlife
V_{LD}	Landscape disturbance
V_{LDD}	Local evidence of dust disturbance
V_{LLD}	Local landscape disturbance
V_{LTK}	Local evidence of thermokarst
V_{MT}	Microtopography
V_{SR}	Species richness
V_{SW}	Anthropogenically derived surface water
V_{TK}	Evidence of thermokarst
WAA	Wetland Assessment Area
$WAA1_{POST}$	WAA1 post-project assessment
$WAA2_{POST}$	WAA2 post-project assessment
$WAA1_{PRE}$	WAA1 pre-project assessment
$WAA2_{PRE}$	WAA2 pre-project assessment

1 Characterization of Regional Wetland Subclasses for North Slope Alaska

1.1 Introduction

This guidebook was developed for the purpose of rapidly assessing wetlands within the North Slope region of Alaska (Figures 1 and 2). The method is designed to support permit review. This method does not identify the importance of wetlands within a watershed, measure specific wetland functions, or determine sufficiency for mitigation on its own. This methodology can be used to inform project alternatives, assess unavoidable impacts, and aid in the determination of sufficiency for mitigation.

This guidebook begins with a description of the North Slope, including summary information regarding the spatial extent of the area, climate, topography, soils, vegetation, fauna, and hydrology of the region. Additionally, a description of the wetland classes occurring within the region is provided.

Figure 1. Arctic Foothills (AF) and Arctic Coastal Plain (ACP) North Slope Region of Alaska. The region north of the Brooks Range comprises the reference domain addressed by this rapid wetland assessment method. Reference data were collected at 88 sample locations (not all data collection locations are visible due to map scale).

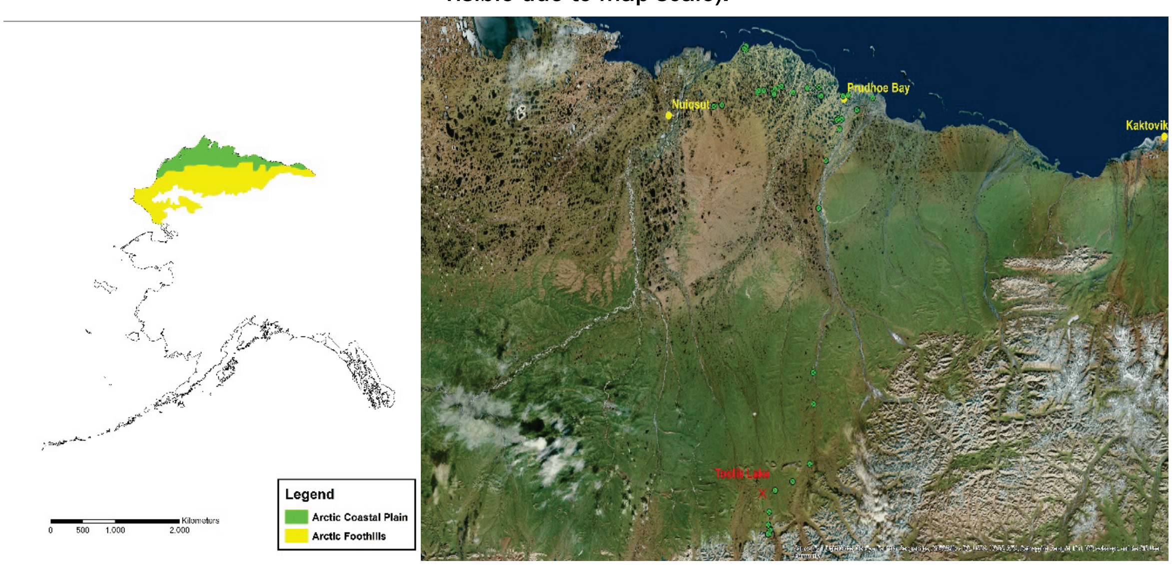
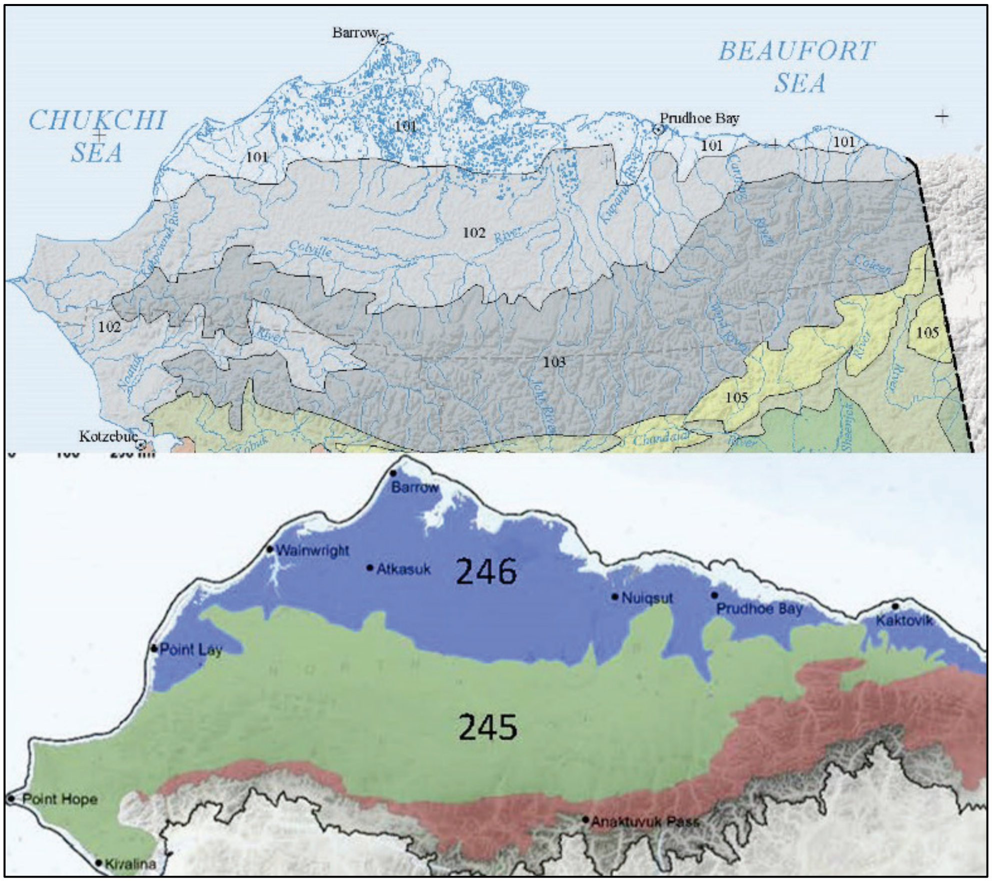


Figure 2. Reference domain of the North Slope region as defined by Ecoregion and MLRA.



The development of the assessment guidebook followed the guidance provided by Smith et al. (2013) for wetland assessments including: (1) ecosystem classification, (2) assessment variable and equation calibration based upon reference data, (3) a written protocol for data collection, (4) peer review, and (5) verification of results. This guidebook was developed and underwent peer review with the input of a multi-agency, interdisciplinary development team including wetland scientists from USACE, USEPA, USFWS, USDA-NRCS, academia, and experts from the private sector. Background information about wetland classification and rapid wetland assessment development procedures can be found in the following documents:

- A hydrogeomorphic classification for wetlands (Brinson 1993). https://wetlands.el.erdc.dren.mil/literature.html
- Hydrogeomorphic (HGM) Approach to assessing wetland functions: Guidelines for developing guidebooks (Version 2) (Smith et al. 2013). https://wetlands.el.erdc.dren.mil/procedure.html

The assessment equations utilized within this guidebook were calibrated using data from reference wetlands within the region including areas located near the Toolik Lake Long-Term Ecological Research Station, Prudhoe Bay, Kuparuk, Oliktok Point, Milne Point, the Miluveach River, and along the Dalton highway (Figure 1). The methodology is applicable throughout the North Slope region as defined within. The assessment equations may be refined on a regional or sub-regional basis to account for observed differences in select variables based upon the availability of additional data (Smith et al. 2013). For example, additional reference data may be collected and used to recalibrate assessment equations (Summers et al. 2017).

1.2 Reference domain

The reference domain (i.e., area of application) for this guidebook is collectively referred to as the North Slope. The reference domain extends northward from the Brooks Range, encompassing the AF and the ACP Major Land Resource Areas (MLRAs), which approximately correspond to Ecoregions 101 and 102 (Figure 2; Bailey 1995). The reference domain includes expansive landscapes, encompassing nearly 170,000 square kilometers (USDA NRCS 2004; 2006). These regions are comprised of many braided rivers, thousands of lakes, and numerous wetland habitats.

1.3 Wetland classification

Several wetland classification schemes have been applied to wetlands, including areas in the North Slope region. The most common classifications include the HGM approach outlined in Smith et al. (1995) and Brinson (1993), which utilized hydrology source, flow regime, and landscape position, the USFWS classification system (Cowardin et al. 1979), which is based upon water source and vegetative cover, and the North Slope Science Initiative (NSSI 2013), which produced a land cover classification map. Others, including Jorgenson et al. (2009) and Viereck et al. (1992), determined wetland classification based upon a variety of characteristics including vegetation type and growth form, landform, and hydrologic regime (e.g., wet sedge meadow). Table 1 provides a comparison chart for the major wetland classification schemes available for use in the region. Appendix A provides a list of resources that can aid in the determination of wetland classification within the region.

Table 1. Comparison chart of wetland classification schemes available for use on the North Slope region of Alaska.[1]

HGM class	Cowardin	North Slope Science Initiative	Jorgenson et al. (2009)
Flats	PEM, PSS	Wet sedge, Mesic sedge-dwarf shrub tundra, tussock tundra, low-tall willow, dwarf shrub, sparsely vegetated	Low/high centered polygon, moist/wet sedge meadow
Riverine	PEM, PSS	Wet sedge, tussock tundra, low-tall willow	Wet sedge meadow, gravel/vegetated bars
Depression	PEM, PEMC	Low-tall willow, wet sedge	Low centered polygon, moist/wet sedge meadow, drained lake basins
Lacustrine Fringe	PEM, PEMH	Wet sedge, Mesic sedge-dwarf shrub tundra, sparsely vegetated	Moist/wet sedge meadow, low/high centered polygon
Tidal Fringe	EEM	Wet sedge, wet grass (*Puccinellia phryganodes*)	Tidal flat, low/high centered polygon, lacustrine fringe (*Arctophila fluva*)
Slope	PEM, PSS	Tussock tundra, tussock shrub tundra, birch ericaceous low shrub	Moist/wet sedge meadow

The rapid wetland assessment described herein utilizes the HGM wetland classification approach. Wetland classifications based upon other schemes should be translated into HGM classes contingent upon analysis of available data (e.g., aerial images, GIS layers, on-site observations) in conjunction with Table 1. The HGM classification scheme is selected because: (1) HGM addresses all of the wetland types occurring in the North Slope region, and (2) each of the wetlands observed during assessment development can be described using a single HGM class, whereas a subset of the wetlands examined were characterized by multiple classes using other classification schemes. Each regional wetland class is briefly described below.

[1] Explanation of codes available in Cowardin et al. (1979) Jorgenson et al. (2009). The rapid wetland assessment does not cover streams or open waters (e.g., lakes, ponds)

1.3.1 Flats

The flats wetland class occurs on low gradient areas throughout the North Slope and represents one of the most common wetland types found throughout the region. Most of the flats in the region are characterized by organic surface soil horizons underlain by permafrost consisting of organic and mineral soil materials, often containing gravels. Flats may exhibit microtopographic relief, including the formation of polygonal ground resulting from repeated cycles of freeze-thaw events (Davis 2001). Additionally, many flats wetlands in the region are characterized by areas of low- and high-centered polygons on polygonal ground (Figures 3 and 4). Hydrologic sources supporting flats include direct precipitation, snowmelt, and seasonal thaw of the surface-active layer.

Figure 3. Example of the flats wetland class occurring on ice wedge polygons along the ACP near Utqiagvik (formally known as Barrow), AK. The low-lying linear features are underlain by ice wedges; and the regions in between, which are also permafrost, are composed of organic soil horizons with subsurface horizons that consist of frozen gravels, sands, and silts with an ice-rich matrix. Photo by Thomas Douglas.

Figure 4. Flats wetlands occur throughout the Arctic Foothills, often located in large valleys and basins. Note the presence of microtopography in the image foreground.

1.3.2 Riverine

The riverine class includes those wetlands that are subject to overbank flooding from streams and rivers (Figures 5 and 6) (Brinson 1993; Noble and Berkowitz 2016). Potential hydrologic sources include both overbank and backwater flooding, with most flooding associated with early summer meltwater runoff. A typical backwater flooding scenario occurs when a large stream that is in flood stage prevents the tributary network from draining efficiently, and the low-lying areas associated with those tributaries fill with water. Alternatively, ice dams, high tides, or prevailing ocean winds can prevent efficient drainage of freshwater rivers, thus leading to backwater flooding on the adjacent coastal plain. Riverine wetlands occur primarily along banks, on small gravel and/or vegetated bars within the channels of streams, and on the limited floodplain surfaces adjacent to some channels. Off-channel areas that are subject to overbank flows may be similar to flats wetlands. Riverine wetlands include palustrine wetlands found in the active flood plain.

Figure 5. A riverine wetland located in the ACP region.

Figure 6. Overbank flooding from the Sagavanirktok River breached the Dalton highway during a spring flood event in 2015 (Photo by Loren Holmes, Alaska Dispatch News, May 24, 2015).

1.3.3 Depressions

Depression wetlands occur in abandoned channels, large point bar swales, drained lake basins, and other low-lying areas within the landscape (Figure 7) (Brinson 1993; Noble and Berkowitz 2016). Depression wetlands hold water for extended periods of time due to their size, depth, and ability to collect surface and subsurface flows from an area much larger than the depression itself. They tend to fill following early summer thaw and snowmelt, which is prior to the onset of higher evaporation rates.

1.3.4 Fringe (e.g., lacustrine, tidal, and vegetated shallows)

Fringe wetlands occur along the perimeter of water bodies that maintain an open water zone year round (Figure 8). Fringe wetlands occur in the fluctuation zone of the water body, which supplies the major source of hydrology. Fringes can be differentiated from depression wetlands by the fact that in fringe wetlands, the dominant hydrologic source is overbank flow from lakes or tidal fluctuations in which hydrodynamics remain bidirectional. Conversely, depression wetland hydrodynamics are dominated by vertical hydrodynamics with hydrologic sources including return flow from surrounding surface and/or groundwaters and interflow. A large number of fringe wetlands occur along the shores of freshwater lakes and along the shoreline of the Beaufort and Chukchi Seas within the North Slope region. Although freshwater and tidal fringe wetlands exhibit different hydrologic sources and hydrodynamics, they share several similarities including low degree of topographic relief, low species richness compared to other HGM wetland classes, and consistently saturated or inundated soil conditions. As a result, for the purposes of this wetland assessment, fringe wetlands include both freshwater lacustrine and tidal fringe areas.

Tidal fringe wetlands occur along coasts and estuaries and are under the influence of the Beaufort Sea tides (approximately 0.3 m) or Arctic Ocean. These wetlands intergrade landward with riverine wetlands where tidal current diminishes and riverflow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. These fringe wetlands are dominated by *Puccinellia phryganodes*.

Figure 7. Depression wetlands located in the AF (top) and ACP (bottom).

Figure 8. Lacustrine fringe dominated by *Arctophila fulva* (top) and tidal fringe wetlands containing *Puccinellia spp*. (bottom).

Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. In some cases, these wetlands consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge; the latter dominates where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional and usually controlled by water level fluctuations such as seiches in the adjoining lake. Lacustrine fringe wetlands are indistinguishable from depressional wetlands where the size of the lake becomes so small relative to fringe wetlands that the lake is incapable of stabilizing water tables. Lacustrine wetlands lose water by flow returning to the lake or ocean after flooding, saturation surface flow, and evapotranspiration. Organic matter normally accumulates in areas sufficiently protected from shoreline wave erosion. Typical plant communities are dominated by four-leaf mares tail (*Hippuris tetraphylla*) and pendant grass (*Arctophila fulva*) (Shafer 1998).

1.3.5 Slope

Throughout the North Slope, slope wetlands occur where (1) there are slope breaks (i.e., topographic position within the landscape) or (2) geologic conditions result in the discharge of groundwater into the wetland (Figure 9). Seasonally or permanently frozen soil layers may maintain high water tables during portions of the growing season, resulting in the formation of slope wetlands on a variety of elevation gradients ranging from steep hillsides to slight slopes. Shallow groundwater or interflow discharging at the land surface provides the dominant water source in slope wetlands areas that contain permafrost; this includes water held above frozen soil. Direct precipitation contributes as a secondary hydrologic source. Slope wetlands can be confused with flats wetlands; however, in flats wetlands, precipitation in combination with melting snow and ice represent the primary water source. In slope wetlands, the dominant hydrodynamics occur downslope as unidirectional flow at or just below the soil surface. Slope wetlands lose water mainly through surface flow, shallow subsurface flow, and evapotranspiration. The convergence of flows occurs in zones at the margin of incipient channels that receive water from more than one direction.

Figure 9. Slope wetland located within the AF region.

1.4 Description of the North Slope region

The North Slope is largely comprised of undeveloped lands including wildlands interspersed with sparsely populated settlements, hunting camps, and native Alaskan villages including Anaktuvuk Pass, Atqasuk, Utqiagvik, Kaktovik, Nuiqsut, Point Hope, Point Lay, and Wainwright. Development and infrastructure occurs within the ACP, including the Prudhoe Bay oil field complex, the northern portion of the Trans-Alaska Pipeline, and the Dalton Highway (i.e., Haul Road) (USDA NRCS 2004).

Traditional land use within the North Slope consists of subsistence hunting, fishing, and gathering. Current land use changes that directly or indirectly impact wetlands in the region include the construction of roads and ice roads, gravel mines and pads, air strips, and other infrastructure; ATV trails; dust from roads and other activities; oil and gas development; surface water extraction; impoundments; improved drainage activities; and expansion of villages and hunting camps. Potential ecological impacts due to land use include activities that bury or disturb organic soil surface layers that insulate and protect underlying permafrost layers, which lead

to the development of thermokarst. Thermokarst, a form of periglacial topography that resembles karst and has hollows that are produced by the selective melting of permafrost, results from permafrost instability. Development of thermokarst leads to degradation of soil structure and an increase in surface water ponding, which affects albedo, vegetative communities, local hydrology, and nutrient cycling. Other land use changes that impact albedo, the proportion of the solar radiation reflected upon the Earths' surface, also have the capacity to alter soil stability. Any activity that disturbs surface organic layers and disrupts thermal balance within the soil has the capacity to impact soil stability and wetlands functions including habitat, hydrology, and biogeochemical cycling (Davis 2001). Additionally, oil spills and other sources of pollution resulting from industrial development within the region are major concerns.

1.5 Physiography

The AF is comprised of gently rolling hills that extend along the northern border of the Brooks Range, a 1,100 km (700 mi) east-west mountain range that is the northern extension of the northern Rocky Mountains (Wahrhaftig 1965; USDA NRCS 2004). The topography of the AF ranges from broad, rounded hills to nearly level basins and river valleys (USDA NRCS 2004). The ridges, buttes, and mesas, comprised of sedimentary rocks, divide the alluvial valleys and areas characterized by glacial moraine. The AF encompasses an area of approximately 11 million square kilometers (MLRA 245) (USDA NRCS 2004). Fresh water lakes and streams occur throughout the AF, with some of the streams freezing solid each winter. Large aufeis deposits, sheets of ice that form during winter months when successive flows freeze along stream banks and river valleys, last into the summer months in some areas (ADFG 2006; USDA NRCS 2004). Elevation in the AF ranges from 200 m (655 feet) at the northern boundary with the ACP to about 610 m (2,000 feet) in the southern part located along the border with the Northern Brooks Range Mountains.

The ACP consists of level to gently rolling plains rising from the Beaufort Sea and extending southward to the AF (Wahrhaftig 1965). It is dotted with thousands of small to medium-sized lakes and interconnecting wetlands (NSSI 2013). Numerous lakes characterize the area, many of which are elongated thaw lakes that are oriented north-northwest. The elevation ranges from sea level to 200 m (656 feet).

1.6 Climate

The AF is characterized by a dry, polar climate that has short growing seasons and long, cold winters (NSSI 2013). Average annual temperatures range from -12.2 to -7.8 °C (10-18 °F), with colder temperatures occurring at higher elevations (USDA NRCS 2004). Average annual precipitation varies from less than 254 mm (10 in) at lower elevations, to 381–508 mm (15–20 in) at higher elevations to the south. Average annual snowfall ranges from 102–152 cm (40–60 in) with fewer than 10 days to 55 days of frost-free period ranges. The growing season is characterized by the period during which direct observation of vegetation green-up, growth, and maintenance occur both above and below ground (USACE 2007). In the absence of direct observations, Markon (2001) estimated the growing season within the AF to occur June 7 through September 21.

The ACP is also characterized by a dry, polar climate that has short growing seasons and long, cold winters. Within the interior ACP, temperatures are slightly warmer in summer months and increased seasonal moderation occurs closer to the coast (NSSI 2013). The average annual temperature ranges from -15 to -10 °C (8 to 14 °F). Although freezing temperatures are possible any month of the year, the ACP experiences an average of 5 to 20 frost-free days per year. Average annual precipitation ranges from 102–152 mm (4–6 in), with average annual snowfall ranging from 50–102 cm (20–40 in). As described above, direct observation best determines vegetative growth; however, estimated growing season dates within the ACP occur June 20 to September 18 (Markon 2001; USACE 2007). Winds can cause drifting of snow across portions of the ACP and AF.

1.7 Soils

The soil order that dominates the reference domain is Gelisols, which comprise approximately 95% of the region (USDA NRCS 2006). Gelisols are characterized by the presence of permafrost within the upper 2 m of the soil surface (Davis 2001; Buol et al. 2011). Permafrost plays an important role in the vegetation, hydrology, fauna, and overall function of wetlands within the reference domain. Entisols, Inceptisols, and other soil orders comprise less than 1% of the region's soil types; nonsoil areas (e.g., rock or ice) account for 4% of the landscape. The soils in this area possess a pergelic soil temperature regime, with most having an aquic soil

moisture regime and mixed mineralogy. Soils are generally shallow to moderately deep over permafrost (Bridgham et al. 2001).

Soil microbes use carbon compounds found in organic matter as an energy source. However, the rate at which soil microbes utilize organic carbon is considerably lower in a cold, saturated, and anaerobic environment than under aerobic conditions (Reddy and DeLaune 2008). Therefore, in the seasonally thawed and saturated soils of the reference domain, partially decomposed, organic matter accumulates. The result is often the development of thick organic layers, such as peat or muck, or dark, organic-rich mineral layers with underlying layers remaining seasonally or permanently frozen. Underlying soil layers often consist of permanently frozen silt loams, which are frequently associated with large amounts of gravel and other coarse materials (Buol et al. 2006).

1.8 Hydrology

The AF and ACP contain many rivers that originate in the Brooks Range (ADFG 2006). Rivers are often confined to a single, moderate gradient, meandering channel, with braided channels occurring in low gradient areas. The Colville River is the largest drainage in the region, with other major rivers also in the region including the Canning and Sagavanirktok Rivers (USDA NRCS 2004). The ACP consists of thousands of small to medium-sized lakes. Many of the lakes within the ACP are elongated thaw lakes that are principally oriented north-northwest (NSSI 2013). The AF region contains fewer lakes than the ACP. The majority of the lakes within the reference domain remain shallow with typical depths less than 2 m.

The presence of permafrost plays a major role in maintaining the wetland hydrology of the region. As seasonal thaw occurs, saturation and inundation of upper soil horizons is common and result in the formation of a seasonal active layer. The underlying permafrost provides a shallow, restrictive layer allowing the surface water table to perch for extended periods of time. As a result, the region is predominantly wetlands. Hydrologic sources within the reference domain include seasonal flooding along rivers and streams, snowmelt, direct precipitation, shallow groundwater discharge, and coastal flooding. Wetland hydrology is more prevalent in the early summer following spring thaw, break up, associated sheet flow over the land surface, and overbank flooding from streams and rivers. Evapotranspiration peaks in August, although near-surface saturation commonly predominates throughout much of the growing season.

1.9 Vegetation

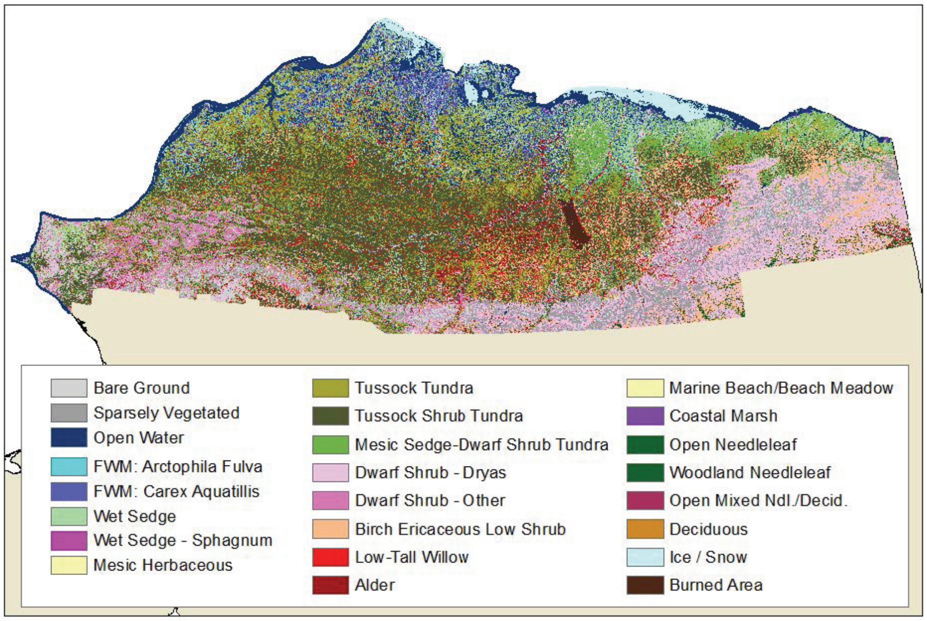
The AF is dominated by expanses of shrub-sedge tussock tundra with willow (*Salix* spp.) thickets along rivers and dryas (*Dryas* spp.) tundra along ridges. Bare soil and bedrock also occur in the region with lichens and scattered herbaceous vegetation. Mesic areas, with deeper soils (e.g., depressions and saturated sites) consist of willow (*Salix* spp.), ericaceous scrub-shrub, mesic graminoid herbaceous communities, and tussock forming sedges. Valleys within the AF consist of a mix scrub-shrub vegetation that is dominated by willow (*Salix* spp.), dwarf birch (*Betula nana*), and alder (*Alnus* spp.), among others.

The ACP supports vegetation that is primarily adapted to wet soil and cool climatic conditions, which consist of sedges, sedges-grasses, and sedge-moss meadows (USDA NRCS 2006). Floodplain vegetation consists of willow scrub-shrub and scattered herbaceous vegetation. Commonly observed, non-floodplain areas support dwarf shrub conditions with dryas, black crowberry (*Empetrum nigrum* L.), ericaceous shrubs, and dwarf willow. Thin, rocky soils support lichen and low-growing herbaceous vegetation, with bare soil and bedrock in some locations.

1.9.1 Land cover types

In 2013, the NSSI produced a land cover map defining 24 land cover types that represent approximately 24 million hectares (ha) (60 million acres) occurring north of the Brooks Range (Figure 10). The four most prevalent land cover types were: tussock shrub tundra (24%), tussock tundra (12%), dryas dwarf shrub (10%) and wet sedge meadow tundra (9%), accounting for approximately 55% of the total area. The vegetation associated with each of these common land cover types is described below. Table 1 provides a comparison chart for interpolating between NSSI data and the HGM classification system.

Figure 10. North Slope Land Cover types (NSSI 2013).



The tussock shrub tundra land cover type occupies approximately 24% of the landscape. This cover type occurs within both the ACP and AF (Viereck et al. 1992; NSSI 2013). Common plant communities include dwarf birch (*Betula nana*), diamond-leaf willow (*Salix pulchra*), marsh Labrador-tea (*Rhododendron tomentosum*) and bog blueberry (*Vaccinium uliginosum*) (NSSI 2013). Tussock-forming vegetation is primarily tussock cotton-grass (*Eriophorum vaginatum*) with Bigelow's sedge (*Carex bigelowii*) in some areas. Shrub/subshrub species include low-bush cranberry (*Vaccinium vitis-idaea*) and black crowberry. Forbs often include field horsetail (*Equisetum arvense*) and cloudberry (*Rubus chamaemorus*). Nonvascular plants include sphagnum (*Sphagnum spp.*), splendid feather moss (*Hylocomium splendens*), turgid aulacomnium moss (*Aulacomnium turgidum*), and elongate dicranum moss (*Dicranum elongatum*). Water sedge (*Carex aquatilis*), tall cotton-grass (*Eriophorum angustifolium*) or Chamisso's cotton-grass (*Eriophorum chamissonis*) are observed on high-centered and low-centered polygons.

The tussock tundra land cover type occupies 12% of the landscape, and occurs within both the ACP and the AF (NSSI 2013). This cover type is similar to the tussock shrub tundra, with the addition of bog blueberry added to the presence of shrub species. This cover type includes tussock cotton-grass as the primary tussock-former, with spruce muskeg sedge sometimes occurring as dominant or co-dominate. On high-centered and low-centered polygons, water sedge, tall cotton-grass or Chamisso's

cotton-grass occur. Nonvascular species include sphagnum, splendid feather moss, turgid aulacomnium moss, and elongate dicranum moss.

The dryas dwarf shrub land cover type occupies 10% of the landscape. This cover type occurs primarily within the AF, but is observed in some portions of the ACP (NSSI 2013). The vegetation of this land cover type includes eight petal mountain-avens (*Dryas octopetala*) on upper floodplain terraces, entireleaf mountain-avens (*Dryas intergrifolia*) on ridges and sideslopes, white arctic mountain heather (*Cassiope tetragona*), alpine bearberry (*Arctostaphylos alpina*), bog blueberry, and net vein willow (*Salix reticulata*), field horsetail, and Canadian singlespike sedge (*Carex scirpoidea*). Non-vascular species include rhytidium moss (*Rhytidium rugosum*), splendid feather moss, navel lichen (*Umbilicaria spp.*), racomitrium moss (*Racomitrium lanuginosum*) and biological soil crusts.

The wet sedge land cover type occupies 9% of the landscape. This cover type is common in both the AF and ACP (NSSI 2013). Within the ACP, this cover type dominates the low-centered polygons. In the AF, wet sedge communities occur in areas of enhanced soil moisture due to shallow groundwater within regions of permafrost. Vegetation in the AF is dominated by water sedge, tall cotton-grass, or creeping sedge (*Carex chordorrhiza*). At the perimeter of the low-centered polygons, shrub species occur and include dwarf birch, Alaska bog willow (*Salix fuscescens*), bog blueberry, and bog rosemary (*Andromeda polifolia*). Common non-vascular species include aulacomnium mosses, scorpidium moss (*Scorpidium scorpioides*), drepanocladus moss (*Drepanocladus spp.*), and sphagnum moss.

Low-centered polygon interiors are often dominated by water sedge and tall cotton-grass, while the elevated perimeters support low shrubs and tussocks. Common shrub species include dwarf birch, diamond-leaf willow, marsh Labrador tea, low-bush cranberry, and black crowberry. Sedges include tussock cotton-grass and Bigelow’s sedge. Non-vascular plant species include sphagnum, polytrichum moss (*Polytrichum strictum*), and splendid feather moss.

1.10 Fauna

The North Slope provides habitat to a diverse array of wildlife (USDA NRCS 2004; ADFG 2006) (Figures 11–17). The wetlands within the domain provide important pre-breeding, nesting, brood-rearing, and fall staging

habitats for over 8 million breeding and migrating birds (Johnson and Herter 1989; USDOI-BLM 2012). Birds migrate to the region for abundant summer food resources, long day length, and reduction in predator density and parasite vulnerability compared to more southern habitats (Boelman et al. 2015). Over 90 species of birds, including seabirds, loons, waterfowl, shorebirds, raptors, passerines, and ptarmigan occur within the reference domain. A majority of these species are present only during the nesting season (late May through October). Examples of nesting waterfowl species include Greater White-fronted (*Anser albifrons*), Snow (*Chen caerulescens*), and Brant Geese (*Branta benicla*); Tundra Swans (*Cygnus columbianus*); Common (*Somateria mollissima*), King (*S. spectabilis*), and Spectacled eiders (*S. fischeri*); and Yellow-billed Loons (*Gavia adamsii*). Additionally, the bulk of the U.S. breeding population of Long-billed Dowitcher (*Limnodromus scolopaceus*), Dunlin (*Calidris alpina*), and Semipalmated (*C. pusilla*), Pectoral (*C. melanotos*), Buff-breasted (*Tryngites subruficollis*) and Stilt Sandpipers (*C. himantopus*) nest in the region. Collectively, more than 6 million birds are estimated to breed on the National Petroleum Reserve-Alaska alone (ADFG 2006). Some species, such as rock (*Lagopus muta*) and willow ptarmigan (*L. lagopus*), common raven (*Corvus corax*), gyrfalcon (*Falco rusticolus*), and snowy owl (*Bubo scandiacus*) may occur in the area year round.

Figure 11. A gray wolf (*Canis lupus*) traversing a depression wetland habitat within the AF.

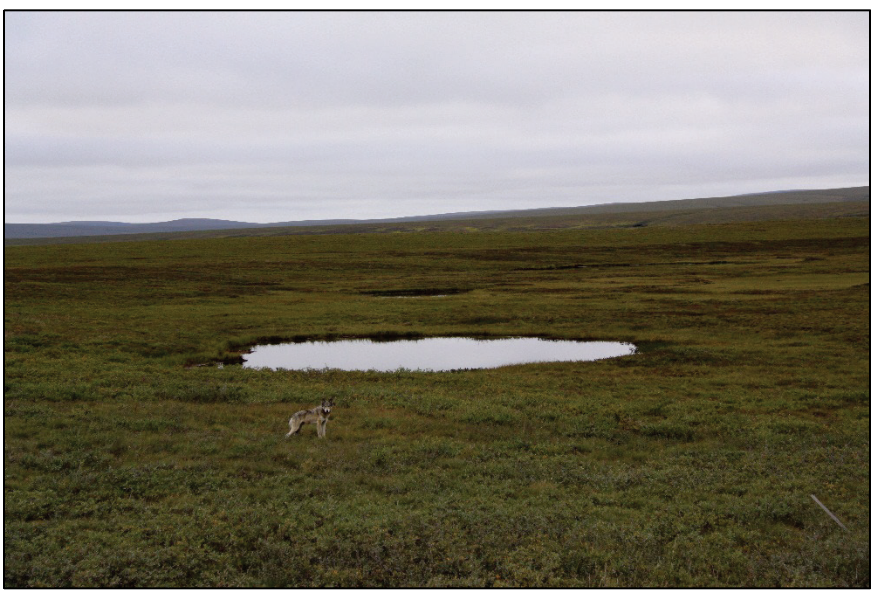


Figure 12. A tundra swan (*Cygnus columbianus*) feeding adjacent to a lacustrine fringe wetland of the ACP.

Figure 13. Caribou (*Rangifer tarandus*) moving across a tidal fringe wetland near the Beaufort Sea within the ACP.

Figure 14. An Arctic Fox (*Vulpes lagopus*) outside its den site adjacent to a lacustrine fringe wetland within the ACP.

Figure 15. Muskoxen (*Ovibos moschatus*) in a flats wetland adjacent to the Dalton Highway within the ACP.

Figure 16. A brown bear (*Ursus arctos*) drinking from a pool adjacent to a riverine wetland near the Dalton Highway within the AF Region.

Figure 17. A Ptarmigan (*Lagopus* sp.) hiding within a slope wetland within the AF.

The AF provides important habitat for an array of fauna, which includes offering den sites for bears and wolves and supplying important habitat for muskoxen (*Ovibos moschatus*), arctic ground squirrels (*Spermophilus parryii*), Smith's Longspurs (*Calcarius pictus*), and Peregrine falcons (*Falco peregrinus*). The moist tundra habitat of the foothills offers nesting habitat for Baird's (*Calidris bairdii*) and Stilt and Buff-breasted Sandpipers, with Ptarmigans and Long-tailed Jaegers (*Stercorarius*

longicaudus) transitioning from the AF to the ACP to breed. The tundra environment of this region also provides nesting habitat for small mammals including the insular vole (*Microtus abbreviatus*).

Several caribou (*Rangifer tarandus*) herds utilize the North Slope and remain an important species for subsistence hunting in this region (ADFG 2006). The Central Arctic caribou herd calves on the ACP and seek a mosquito-relief habitat along the coast during summer months. The Teshekpuk Lake Caribou herds generally calve closer to the coast near Teshekpuk Lake. The Porcupine herd calves east of the Canning River on the ACP and move inland to foothills post-calving. The Western Arctic herd uses the windier foothills of the western portion of the domain for calving and mosquito-relief habitat (USDOI-BLM 2012). Lakes within the AF contain Arctic char (*Salvelinus alpinus*), lake trout (*S. namaycush*), and whitefish (*Coregonus sp.*). Along the west coast, larger rivers provide spawning habitat for Dolly Varden char (*Salvelinus malma*) and five species of Pacific salmon (*Oncorhynchus* spp.) (ADFG 2006).

The ACP provides important habitat for muskox, wolverine (*Gulo gulo*), moose (*Alces alces*), lemmings (*Lemmus lemmus*), polar bears (*Ursus maritimus*) and arctic foxes (*Vulpes lagopus*) near the coast, with gray wolves and brown bears (*Ursus arctos*) found throughout (USDOI-BLM 2012). Barren ground shrews (*Sorex ugyunak*), singing voles (*Microtus miurus*), and arctic ground squirrels also inhabit the ACP. Coastal waters offer habitat for walruses (*Odobenus rosmarus*), minke (*Balaenoptera acutorostrata*), beluga (*Delphinapterus leucas*), gray (*Eschrichtius robustus*), and bowhead (*Balaena mysticetus*) whales, as well as bearded (*Erignathus barbatus*), spotted (*Phoca largha*), and ringed (*Pusa hispida*) seals. Many lakes, rivers, and streams in the region do not freeze completely, providing habitat for Arctic grayling (*Thymallus arcticus*), Arctic cisco (*Coregonus autumnalis*), broad whitefish (*C. nasus*), least cisco (*C. sardinella*), and Dolly Varden char in overwintering areas.

2 Assessment Variables, Functions, And Assessment Equations

Data supporting the development and calibration of this rapid wetland assessment were collected at 88 sampling areas within the North Slope. The sampled wetland areas encompassed each of the wetland classes described above and exhibited the range of alterations reported by the development team. The remote nature of the region and the short growing season limits the time period during which on-site data can be collected. As a result, the rapid assessment method allows for either (1) an assessment based upon off-site data (remote sensing and desktop tools) only or (2) an assessment using a combination of on-site (field collected data) and off-site data collection. This approach provides a tiered structure, in which the best available data are utilized to determine assessment scores. A site visit allows for verification of the accuracy of off-site data and accounts for recent changes that may potentially affect wetland assessment outcomes in the area of interest. USACE may require the collection of on-site data.

2.1 Variables

The following section introduces the variables used in the rapid assessment of wetlands within the North Slope. During the development of this guidebook, over 50 variables were evaluated for inclusion, including over 20 on-site variables and 30 off-site variables. The 13 variables selected displayed utility in differentiating between areas with varying levels of disturbance, proved efficient and easy to measure, and displayed repeatability among users. Each variable was calibrated based upon data collected within the region. The protocol provided in Section 3.0 describes specific approaches for collecting data for each variable. Variables were converted to variable subindex scores ranging from 0 to 1.0 using an assessment calculator. Results were then combined using empirical assessment equations to produce an assessment score for three wetland functions (habitat, hydrology, and biogeochemical cycling) and an on-site modifier (when on-site data are available).

2.1.1 Desktop or remote sensing variables

Off-site variables were based upon analysis of GIS tools, imagery, or other remote-sensing resources. A list of potential off-site data sources is

presented in Appendix A, although other resources may be available. Users should utilize the most current and/or accurate data or information available. The USGS and other federal and state agencies, academia, and private sources provide a number of tools for off-site analysis. Off-site variable data are collected at two spatial scales, 80 m radius and 800 m radius surrounding a data point (Figure 18). The 80 m and 800 m radius areas were selected after evaluating a number of possible scales of data collection. The selected scales were able to account for potential wetland impacts at each of the study areas examined. The following variables were utilized to determine assessment scores for three wetland functions (habitat, hydrology, and biogeochemical cycling):

Variables assessed at the 80 m radius

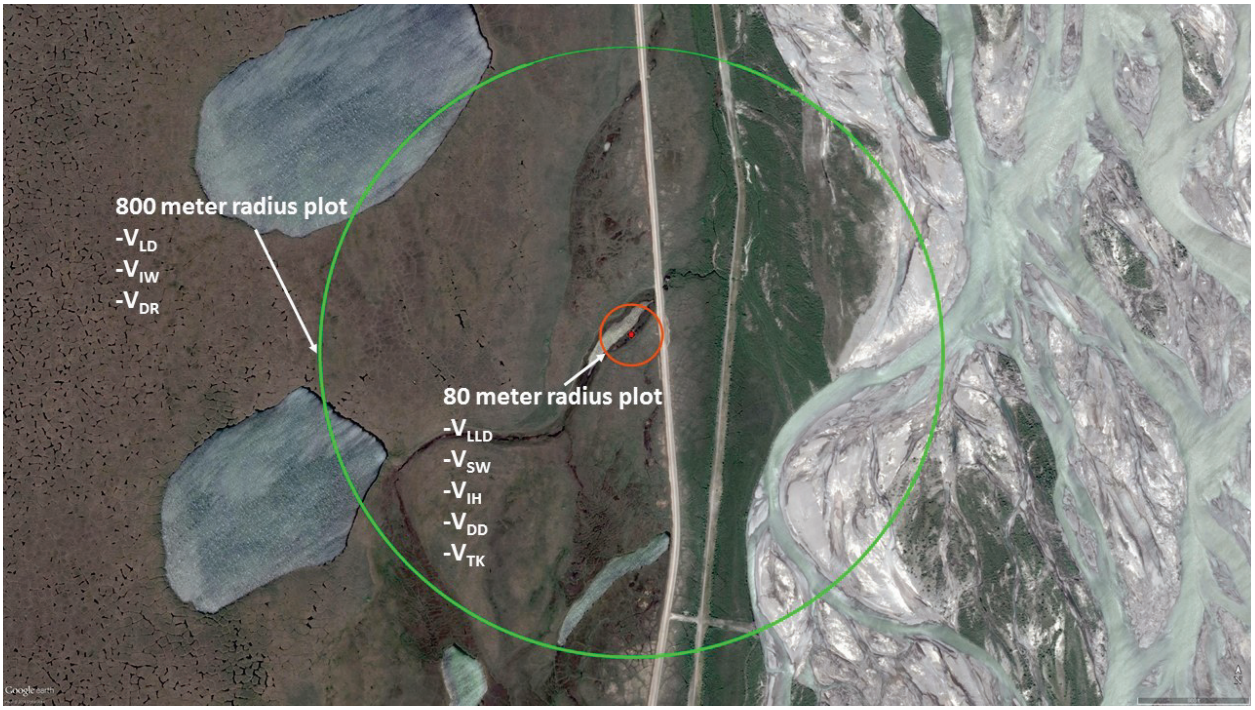
1. Local landscape disturbance (V_{LLD})
2. Anthropogenically derived surface water (V_{SW})
3. Impediment to hydrology (V_{IH})
4. Evidence of dust deposition (V_{DD})
5. Evidence of thermokarst (V_{TK})

Variables assessed at the 800 m radius

1. Landscape disturbance (V_{LD})
2. Impediment to wildlife (V_{IW})
3. Distance to roadway (V_{DR})

Each variable was calibrated or scaled using the data collected within the reference domain. The scaling for each off-site variable is presented in the protocols outlined below. Variable subindex scores can be calculated manually from the graphs presented in Section 3.0 or determined using the wetland assessment calculator provided.

Figure 18. Off-site variable collection occurs at two spatial scales, with five variables (V_{LLD}, V_{IH}, V_{DD}, V_{TK}, and V_{SW}) examined within an 80 m radius circle and three variables (V_{LD}, V_{IW}, and V_{DR}) examined within a larger 800 m radius area that encompasses the 80 m radius circle. Please note that the 80 m radius plot is dead center of the 800 m radius plot.



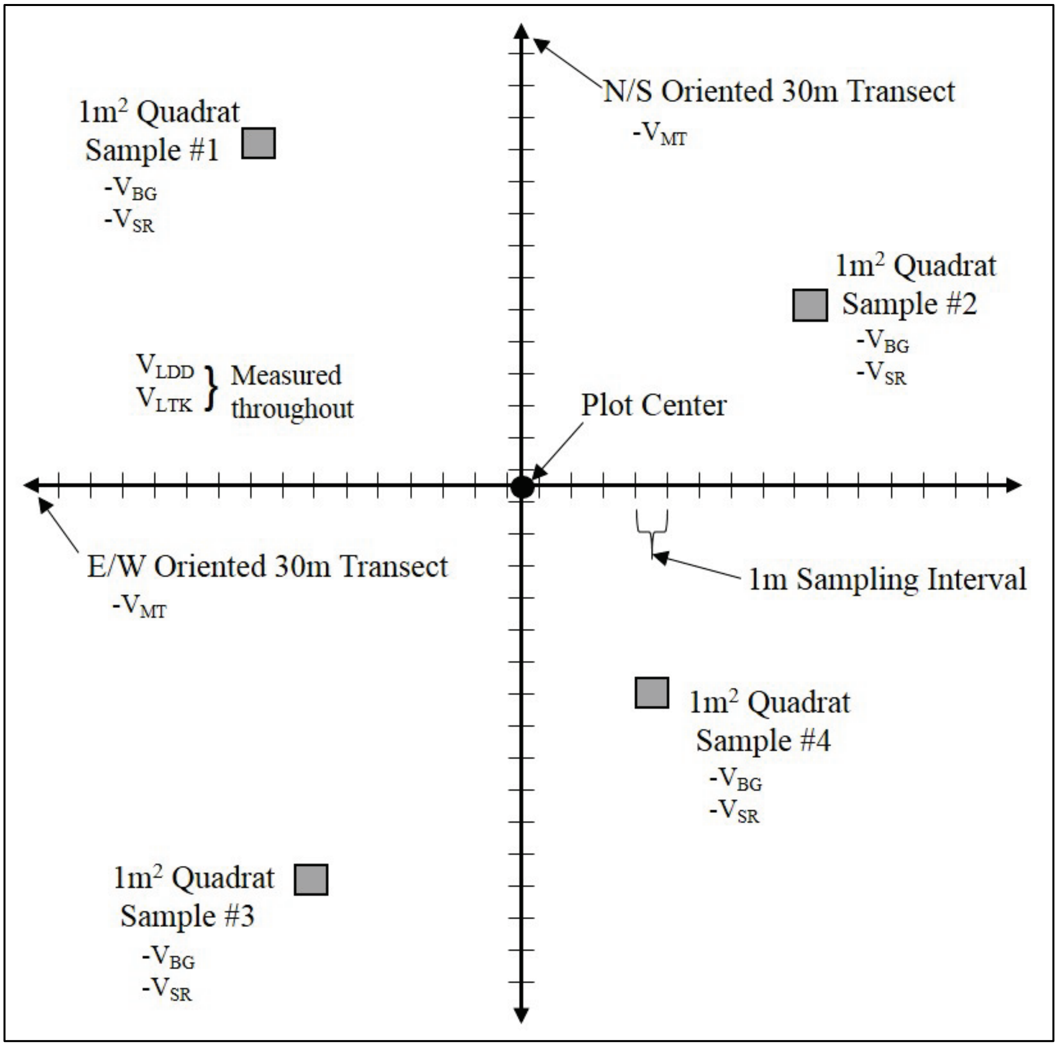
2.1.2 On-site variables

On-site variable data collected during the growing season were supplemented and used in conjunction with off-site variables. As a result, the on-site data should be collected in the same area utilized for the off-site data collection, but confined to the 80 m radius plot described above. The following variables were utilized to determine assessment scores for the on-site modifier.

1. Microtopography (V_{MT})
2. Species richness (V_{SR})
3. Bare ground (V_{BG})
4. Local evidence of thermokarst (V_{LTK})
5. Local evidence of dust deposition (V_{LDD})

Microtopography was collected using two 30 m transects. Species richness and bare ground variables are collected utilizing four 1 m quadrats (Figure 19). Local evidence of thermokarst and dust deposition are presence or absence determinations.

Figure 19. Plot layout for on-site data collection. Thirty meter transects are positioned perpendicularly for the measurement of V_{MT}. A single 1 m quadrat should be located in a representative area within each quarter section for the measurement of V_{SR} and V_{BG}. Observations of local evidence of both dust deposition (V_{LDD}) and thermokarst (V_{LTK}) are made throughout the sample area.



2.2 Wetland assessment equations

This section provides the definition, rationale, characteristics, and assessment equations utilized to quantify wetland functions (e.g., habitat, hydrology, and biogeochemical cycling) and the on-site assessment modifier when on-site data are available. Although the rapid assessment approach does not directly measure wetland functions, surrogate measures related to function have been utilized in a variety of methodologies (Smith et al., 1995; 2013). These surrogate measures have been successfully related to wetland functions in several studies (Noble et al., 2014). For example, Summers et al. (2015) demonstrated the capacity of rapid assessment approaches to

infer habitat functions in salamander communities; Berkowitz et al. (2014) showed strong relationships between rapid assessment scores and direct measurements of biogeochemical cycling functions.

The following introduces the empirical equations utilized to calculate assessment scores and provides rationale and justification for selection and weighting of the wetland assessment. Each assessment equation was derived empirically based upon data collected within the region, direct observation of wetland functional stressors, and input from the assessment development team. The implications of dust deposition and thermokarst to wetland function are also discussed.

2.2.1 Habitat

The habitat function is defined as the capacity of wetlands in the region to provide critical life requisites to the vegetation and wildlife community.

The rationale for selecting the habitat function includes the fact that wetlands are recognized as valuable habitats for a diversity of plants as well as invertebrate and vertebrate animal species. Plant communities, birds, and small and large mammals were selected as the focus of this function. Birds were chosen because they are of considerable public and agency interest, and they respond rapidly to changes in the quality and quantity of their habitats. In addition, birds include diverse and unique species that have strong associations with the different ecological components that characterize wetlands in the reference domain. Birds have been shown to be sensitive indicators and integrators of environmental changes, such as those brought about by human use and alteration of landscapes (Morrison 1986, Croonquist and Brooks 1991).

Examples of potential independent, quantitative measures of this function that could be used to validate the assessment index (Smith et al. 2013) include the combined species richness of plants, birds, and mammals that use regional wetlands throughout the annual cycle. Data requirements for assessment validation include direct monitoring of wildlife communities using appropriate techniques for each taxon. Ralph et al. (1993) described field methods for monitoring bird populations.

Hydrologic or landscape alterations to wetlands have the potential to impact plant and wildlife species. Species with direct dependence on water are highly vulnerable to the placement of fill materials or to wetland

drainage due to human developments. Even partial draining or filling could impact breeding activity because of the length of time needed for nesting, egg development, and maturation of the young. Conversely, artificially increasing the amount of time that surface water is present in a wetland by excavating, changing patterns of albedo, or by augmenting runoff into the wetland can potentially reduce the suitability for plants and animals. Sites with unaltered conditions that have not been subjected to disturbance for long periods support a characteristic vegetation composition and structure. Wildlife species have evolved with and adapted to these conditions. Thus, alterations to wetlands have the potential to change the composition and structure of the plant and wildlife community. Factors other than anthropogenic disturbance, including droughts and catastrophic storms, fire frequency and intensity, competition, disease, browsing pressure, community succession, and natural disturbances, also affect plant and wildlife communities.

Birds and other wildlife found within the region are also known to be impacted adversely by habitat fragmentation. Habitat fragmentation can impact bird nesting areas and access to calving/denning areas in other species. In addition, fragmentation may impact movement corridors to brood-rearing areas as well as access to migration routes. These factors can result in increased predation, nest parasitism, and other impacts (Kessel 1979; Liebezeit et al. 2009; Furness and Greenwood 1993; Nelleman et al. 2003). Area-sensitive species tend to have lower reproductive output in smaller habitat patches, or they simply avoid small patches altogether. Additionally, some species prefer areas characterized by a mosaic of different habitat types.

The assessment equation for habitat incorporates the following variables: Impediment to wildlife (V_{IW}), Distance to roadway (V_{DR}), Landscape disturbance (V_{LD}), and Local landscape disturbance (V_{LLD}). These variables are combined by determining (1) the minimum (MIN) score regarding Impediment to wildlife (V_{IW}) and Distance to roadway (V_{DR}) and (2) the arithmetic mean of Landscape disturbance (V_{LD}) and Local landscape disturbance (V_{LLD}). The two terms are then combined using a simple arithmetic mean:

$$\text{Habitat assessment score} = [\text{MIN}(V_{IW}, V_{DR}) + ((V_{LD} + V_{LLD})/2)]/2$$

The habitat assessment equation includes two equally weighted terms encompassing (1) measures of impedance to wildlife movement, such as roadways or other infrastructure and (2) the degree of landscape disturbance at both site specific and regional scales. For example, areas with high concentrations of roads, pipelines, or other infrastructure can deter or alter wildlife movements, fragment habitat, and decrease habitat quality and quantity. Potential habitat assessment scores range from 0.0 to 1.0, with higher scores corresponding to a lower degree of alteration and a higher potential to provide wetland habitat functions.

2.2.2 Hydrology

The hydrology function is defined as the ability of the wetlands within the region to dissipate energy associated with flow velocity, transport water down gradient, maintain natural soil moisture and surface water levels, and provide waters to streams and rivers at local and regional scales (Woo and Winter 1993; McNamara et al. 1998). Potential independent, quantitative measures that may be used in validating the hydrology function include direct measures of soil moisture, surface water flow, and/or near-surface ground water movements over time.

The rationale for selecting the hydrology function includes the fact that water transport and energy dissipation are fundamental physical functions performed by wetlands throughout the reference domain (Roulet and Woo 1986; Woo and Young 2006). The energy produced by flowing water affects the rate of microbial processes and the amount of sediment, organic matter, and nutrients that are transported down gradient (Chapin et al. 1993). A dramatic increase or decrease in surface water ponding can also impact habitat, permafrost stability, and nutrient cycling dynamics.

The characteristics and processes that influence the capacity of wetlands to dissipate energy and convey water have both natural and anthropogenic origins. Climate, landscape-scale geomorphic characteristics, and characteristics of the soil are factors largely established by natural processes (Rovansek et al. 1996). However, even landscape scale geomorphic characteristics and soils can be altered by anthropogenic alterations.

Human activities may have a profound effect on the amount, timing, and movement of water. Modifications to the landscape such as construction of fill pads, gravel mines, roads, or other infrastructure potentially modify hydrology and affect this wetland function.

The assessment equation for hydrology incorporates the following variables: Impediment to hydrology (V_{IH}), Anthropogenically derived surface water (V_{SW}), Landscape disturbance (V_{LD}), and Local landscape disturbance (V_{LLD}). These variables are combined by determining the (1) arithmetic mean of Impediment to hydrology (V_{IH}) and Anthropogenically derived surface water (V_{SW}) and (2) the arithmetic mean of Landscape disturbance (V_{LD}) and Local landscape disturbance (V_{LLD}). The two terms are then combined using a geometric mean:

$$\text{Hydrology assessment score} = [((V_{IH} + V_{SW})/2) \text{ X } ((V_{LD} + V_{LLD})/2)]^{1/2}$$

The hydrology assessment equation includes two equally weighted terms encompassing (1) measures of impedance to hydrologic flow and the presence of anthropogenically derived surface water and (2) the degree of landscape disturbance at both 80 m radius and 800 m radius scales. For example, areas with high concentrations of infrastructure limit the mobility of surface water, resulting in ponding of water adjacent to fill pads or other structures. Potential hydrology assessment scores range from 0.0 to 1.0, with higher scores corresponding to a lower degree of alteration and a higher potential to provide wetland hydrology functions.

2.2.3 Biogeochemical cycling

The biogeochemical cycling function is defined as the characteristic biotic and abiotic processes of wetlands that alter the concentration and form of nutrients and compounds (Reddy and DeLaune 2008). The rationale for selecting the biogeochemical cycling function includes the fact that these processes encompass the conversion of nutrients and other elements and compounds from one form into another by assimilation into plant biomass, remineralization of those materials when the plant materials decompose, long-term storage of nutrients and compounds in mineral and organic soil fractions, and interaction between aquatic, terrestrial, and atmospheric environmental compartments. This includes the capacity of wetlands to sequester and transform carbon as well as other compounds (including pollutants) (McGuire et al. 2009). Biogeochemical functions are recognized as a primary function that should be considered in relationship to wetland impacts (Mitsch and Gosselink 2007).

A sustained supply of organic carbon in the soil provides for maintenance of characteristic plant communities including annual primary productivity, composition, and diversity (Bormann and Likens 1970). The

plant community (i.e., producers) provides the food and habitat structure (i.e., energy and materials) needed to maintain the characteristic animal community (i.e., consumers). In time, the plant and animal communities function as a source of detritus that serve as the foundation of energy and materials needed to maintain the characteristic community of decomposers. The decomposers break down organic materials into simpler elements and compounds that can reenter the nutrient cycle (Berendse and Jonasson 1992; Jonasson et al. 1999; Jonasson and Shaver 1999).

Biogeochemical cycling is a function of biotic and abiotic processes that result from conditions within and around the wetland (Giblin et al. 1991). In wetlands, carbon is stored within, and cycled among, four major compartments: (a) the soil, (b) primary producers such as vascular and nonvascular plants, (c) consumers such as animals, fungi, and bacteria, and (d) dead organic matter. Due to the low temperatures and short growing season, wetlands in the region store large quantities of carbon, which provide carbon sequestration on a massive scale (Mack et al. 2004). Carbon storage occurs in wetlands because the oxygen needed for aerobic respiration has a rate of diffusion 10,000 times slower in water than in air. Thus, wetlands' anaerobic conditions slow the microbial decomposition of organic matter.

Many wetland plants, called hydrophytes, are unique in that they have adapted to living in water or wet soil environments. Physiological adaptations in leaves, stems, and roots allow for greater gas exchange, permit respiration to take place, and allow the plant to harvest the stored chemical energy it has produced through photosynthesis. Although there is no clear starting or ending point for carbon cycling, it can be argued that it is the presence and duration of water in the wetland that determines the characteristic plant community of hydrophytes and the rate of carbon cycling. In turn, it is the maintenance of the characteristic primary productivity of the plant community that sets the stage for all subsequent transformations of energy and materials at each trophic level within the wetland. It follows that alterations to hydrologic inputs, outputs, or storage and/or changes to the characteristic plant community will directly affect the way in which the wetland can perform this function (Frey and McClelland 2009). It should also be noted that the organic rich wetland soils in the region also play an important role in mercury cycling through the environment and the formation, storage, and distribution of methyl-mercury in the environment (Hammerschmidt et al. 2006).

Abiotic processes that affect retention and cycling of nutrients and other compounds depend primarily on the adsorption of materials to soil particles, the amount of water that passes through the wetland carrying dissolved constituents, the hydroperiod or retention time of water that maintains anaerobic conditions, and the importation of materials from surrounding areas (Shaver et al. 1991; Shaver et al. 1992; Sullivan et al. 2008; Schuur et al. 2008). Natural soils, hydrology, and vegetation are important factors in maintaining these characteristic biogeochemical processes.

Measuring the rate at which carbon or other compounds are transferred and transformed between and within trophic levels would be a potential independent, quantitative measure used to validate the biogeochemical cycling function. However, the time and effort required to make these measurements are well beyond a rapid assessment procedure.

Reference data suggest that land use practices in and around the wetland have great effect on the characteristic plant community structure (i.e., species composition and coverage), diversity, and primary productivity. Changes in hydrology through filling, development of obstructions (e.g., roads, pipelines), increased surface water or ponding, or other changes can have a direct and pronounced effect on the accumulation and decomposition of soil organic matter. Soil organic matter is a characteristic that affects soil oxidation-reduction reactions. Soil alterations also change the physical features to which native plants have adapted. As a result, disturbances have the potential to influence biogeochemical interactions and function.

The assessment equation for biogeochemical cycling incorporates the following variables: Landscape disturbance (V_{LD}), and Local landscape disturbance (V_{LLD}). The biogeochemical cycling assessment score is the minimum value of these two variables:

$$\text{Biogeochemical cycling assessment score} = MIN(V_{LD}, V_{LLD})$$

The biogeochemical cycling assessment equation has one term describing the degree of landscape disturbance at the two scales (80 m and 800 m). For example, areas with high concentrations of infrastructure have the capacity to alter both inputs and outputs of nutrients, water, gases, and other factors that influence biogeochemical cycling. Potential biogeochemical cycling assessment scores range from 0.0 to 1.0, with

higher scores corresponding to a lower degree of alteration and a higher potential to provide wetland biogeochemical cycling functions.

2.3.4 On-site assessment score modifier

Collection of on-site data provide a useful tool to (1) verify determinations made using off-site analysis and (2) further refine assessment results based on using ground based measurements. As noted above, the wetland assessment can be conducted with or without the collection of on-site data. Based upon data gathered during assessment development, collection of on-site data requires <2 hrs per sample location, allowing for a number of on-site assessments to be completed in one day or less (Smith et al. 2013). However, the timing of an on-site assessment is limited to the growing season, when herbaceous vegetation growth can be observed. Efforts should be made to focus on-site data collection during the peak of the growing season when possible.

The on-site assessment score modifier incorporates three variables including: Species richness (V_{SR}), Bare ground (V_{BG}), and Microtopography (V_{MT}). The on-site modifier score is determined using the arithmetic mean of the three variables:

$$\text{On-site assessment score modifier} = (V_{SR} + V_{BG} + V_{MT})/3$$

The on-site assessment score modifier contains one term, which represents the field conditions observed within the project area. Disturbances such as placement of fill material, road construction, dust, and alterations to hydrology or the stability of the permafrost layer impact on-site conditions and result in a decreased assessment score. On-site assessment score modifier values range from 0.0 to 1.0, with increasing values associated with lower levels of disturbance and a high level of ecological function.

Please note, on-site data collection may be required at the discretion of USACE.

2.3.5 Dust deposition and the presence of thermokarst

During development of the rapid wetland assessment, the development team indicated that dust deposition and the presence of thermokarst were important factors negatively impacting wetlands within the region. As a

result, evidence of dust deposition and thermokarst limit the maximum attainable scores derived above for each wetland function and the on-site modifier. Dust deposition and the presence of thermokarst are evaluated at 80 m scale. Procedures for determining the presence of dust and thermokarst and the associated limitation of assessment scores are described in the sample protocol presented below.

3 Assessment Protocol

The following section provides a systematic protocol for application of the rapid wetland assessment including instructions for the measurement of each assessment variable, guidance on determining variable subindex scores, data analysis, and interpretation of results. All data collected for use are recorded on the “Alaska North Slope Region Wetland Assessment” data form (see Section 9.0).

- Step 1. Define the wetland assessment area.

  The wetland assessment area (WAA) should be defined as all or part of an aquatic resource at a proposed project site that is relatively homogeneous in:

  (1) Character (belongs to a single HGM wetland class and is relatively homogeneous with respect to the site-specific criteria used to assess wetland condition [Smith et al. 2013]), (2) Proposed impact, or (3) Proposed mitigation, to be assessed as a single unit (Figures 20 and 21).

Figure 20. Example of a proposed mitigation project area that contains three WAAs (A = flats; B = depression; C = riverine) that represent three undisturbed HGM classes that must each be analyzed separately.

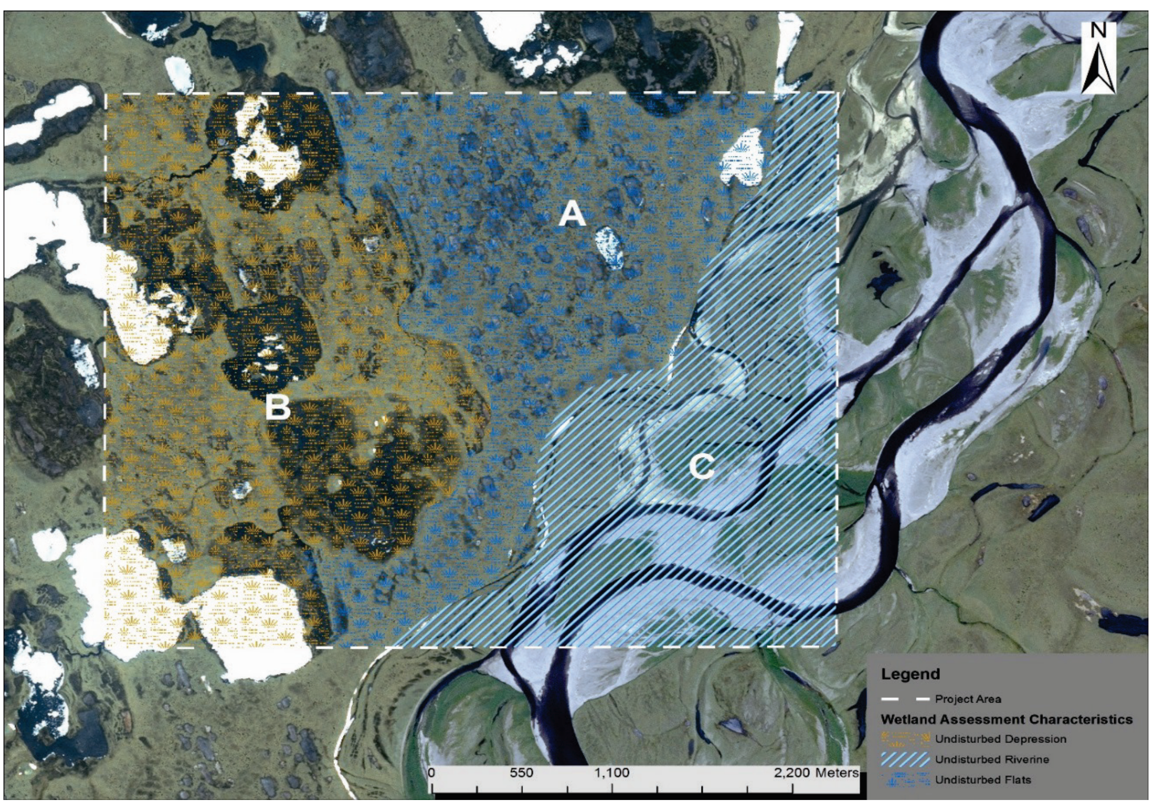
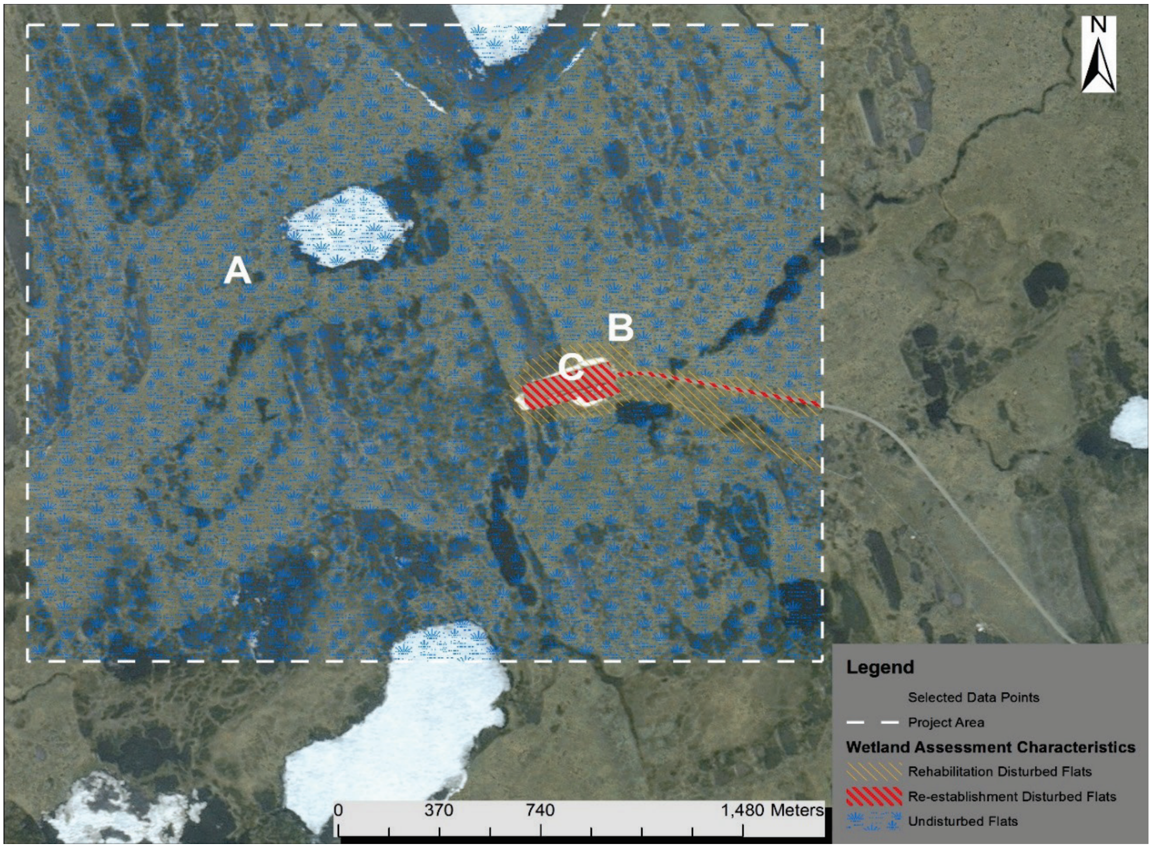


Figure 21. Example of a proposed mitigation project area containing one HGM wetland class. A portion of the wetland is undisturbed and other portions show different levels of disturbance. Note that separate wetland assessment areas are necessary in (A) the portion lacking any sign of disturbance in a flats wetland; this area will be preserved, (B) areas containing some disturbance in a flats wetland as a result of the road and fill pad; this area would undergo rehabilitation, and (C) areas filled by the road and fill pad; this area would undergo re-establishment.



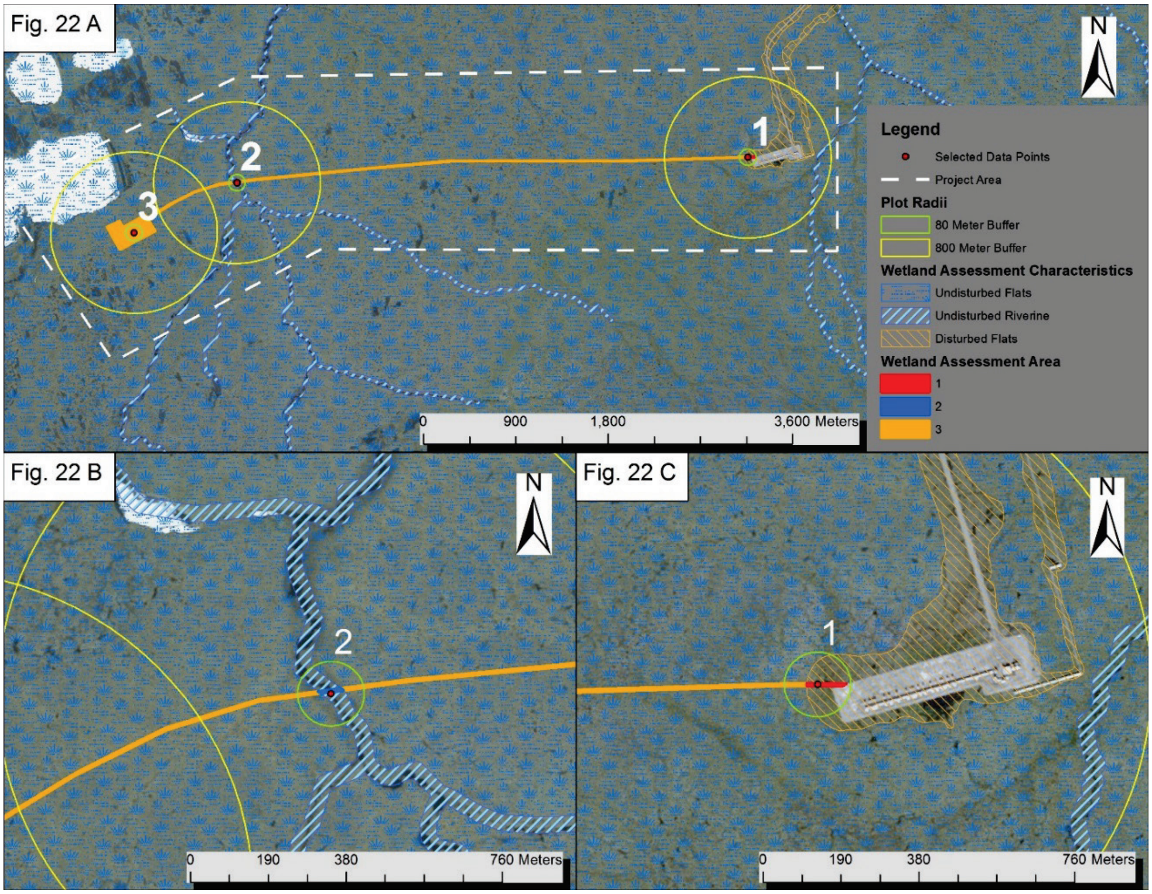
- Step 2. Select data point locations.

  A minimum of one representative data point is required for each WAA (Figure 22).

- Step 3. Collect data.

  Once the data have been collected for each representative data point, individual data point scores are weighted by area to determine the final wetland assessment outcome (see protocol below and scenarios in section 5.0).

Figure 22. The dashed white line identifies the project area. There are two wetland classes present. One wetland class has both disturbed and undisturbed areas. Therefore, three wetland assessment areas are defined. A representative data point is selected for each wetland assessment area: (A) WAA 1, a disturbed flats wetland affected by infrastructure development (i.e., pad and existing road), (B) WAA 2, a riverine wetland, and (C) WAA 3, an undisturbed flats wetland.



3.1 Desktop or remote sensing variable protocol

The collection of off-site variables occurs at two spatial scales, 80 m and 800 m radius areas. Procedures for determining each off-site variable are provided below. The variable measurements are converted to a variable subindex score using the figures provided or the wetland assessment calculator.

3.1.1 Local landscape disturbance (V_{LLD})

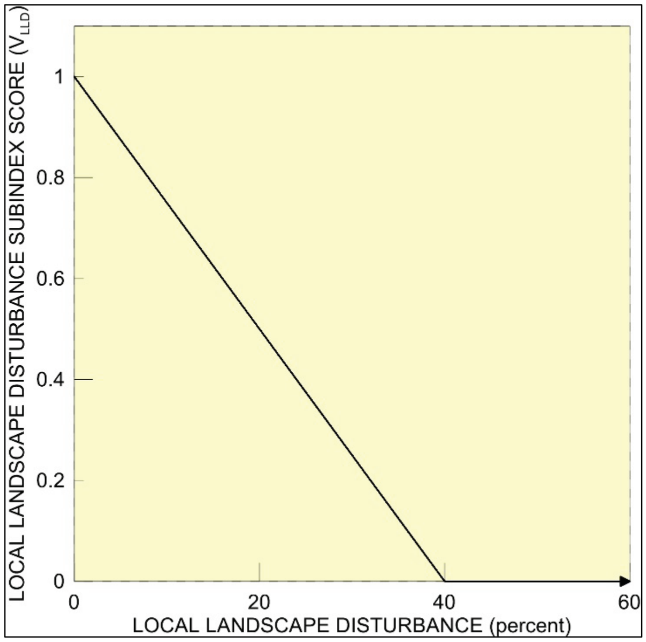
V_{LLD} is defined as the total anthropogenic disturbance quantified as a percentage of the 80 m radius area. Disturbances include, but are not limited to, roads, levees, utility lines, structural features, borrow pits, pads, pipelines, and parking lots. Areas with peculiar coloration and/or textures can often be verified as disturbed by referring to historical aerial images.

The example shown in Figure 23 includes areas occupied by a primary road, a secondary road, and a gravel pad (blue) that cumulatively occupy 23% of the plot. Use the following procedure to measure V_{LLD}:

1. Centered on a representative location within the assessment area, establish an 80 m radius plot.
2. Determine the percentage of the area exhibiting signs of disturbance.
3. Use Figure 24 or the provided wetland assessment calculator to determine the subindex score for V_{LLD}.

Figure 23. Percent V_{LLD} assessed at the 80 m radius. The blue highlighted area contains a primary road, secondary road, and gravel fill pad, which occupy 23% of the plot. As a result, the total disturbed area equals 23%, corresponding to a variable subindex score of 0.43 for V_{LLD}. The portion highlighted in transparent orange represents an area where dust was deposited adjacent to the roadway (see discussion of V_{DD} below).

Figure 24. Association between the percentage of the 80 m radius plot that shows disturbance and the V_{LLD} subindex score.



3.1.2 Anthropogenically derived surface water (V_{SW})

V_{SW} is defined as the total amount of anthropogenically derived surface water, quantified as a percentage of an 80 m radius plot. This variable indicates altered hydrology, human-induced surface water ponding, or alteration of the local geomorphology by removal of the substrate and subsequent collection of surface water. These areas include water collected in excavations (e.g., borrow pits, mines), water accumulated against man-made linear features due to impaired drainage, and surface water associated with disturbances to soil stability abutting structures, pads, or fill areas. Open surface water should only be counted if it is conspicuously linked and situated in proximity to an anthropogenic activity. In Figures 25 and 26, Site A exhibits anthropogenic surface water (blue) associated with a road, pad, and utility line, occupying 15% of the plot, which corresponds to a variable subindex score of 0.1 (see Figure 27). Site B contains a borrow site (blue) adjacent to the stream and occupies approximately 35% of the plot and receives a subindex score of 0.0 (see Figure 27). In fact, all sites where the 80 m radius plot exhibits a V_{SW} of ≥ 16% will score 0.0. Use the following procedure to measure V_{SW}:

1. Centered on a representative location within the assessment area, establish an 80 m radius plot.
2. Determine the total percentage of the plot occupied by anthropogenically derived surface water.
3. Use Figure 27 or the provided wetland assessment calculator to determine the subindex score for V_{SW}.

Figure 25. Percent V_{SW} assessed at the 80 m scale, shown in transparent blue. Site A exhibits anthropogenically derived open water adjacent to the road and pipeline; Site B contains open water associated with a large borrow site.

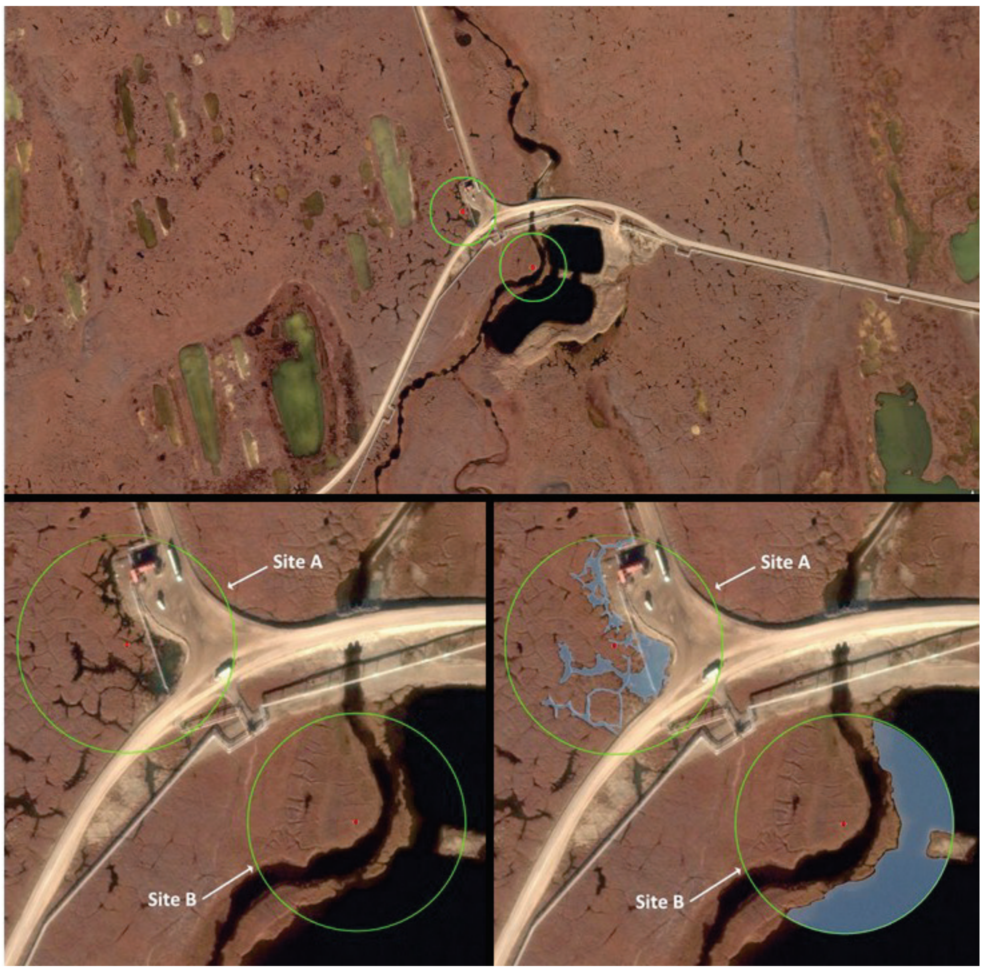
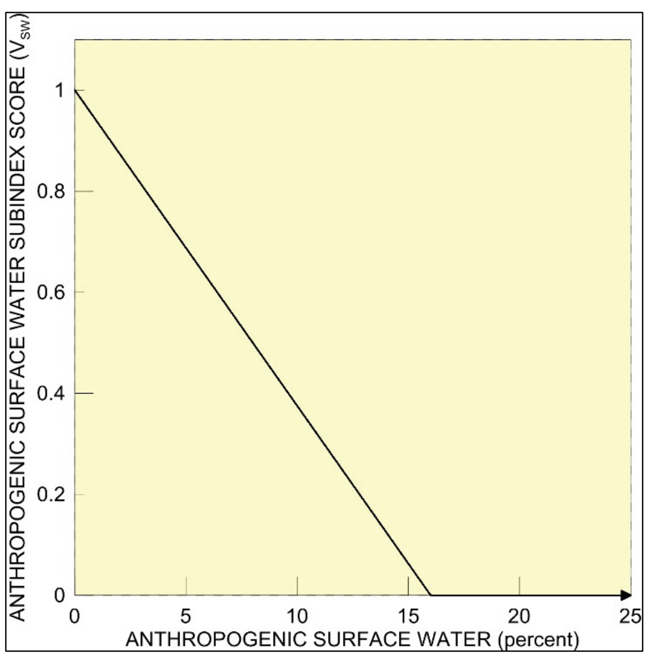


Figure 26. Ground view of V_{SW} adjacent to heavily disturbed area. Placement of fill material disrupted drainage, which led to an increase in surface water.

Figure 27. Association between the percentage of the 80 m radius area occupied by V_{SW} value and the V_{SW} variable subindex score.



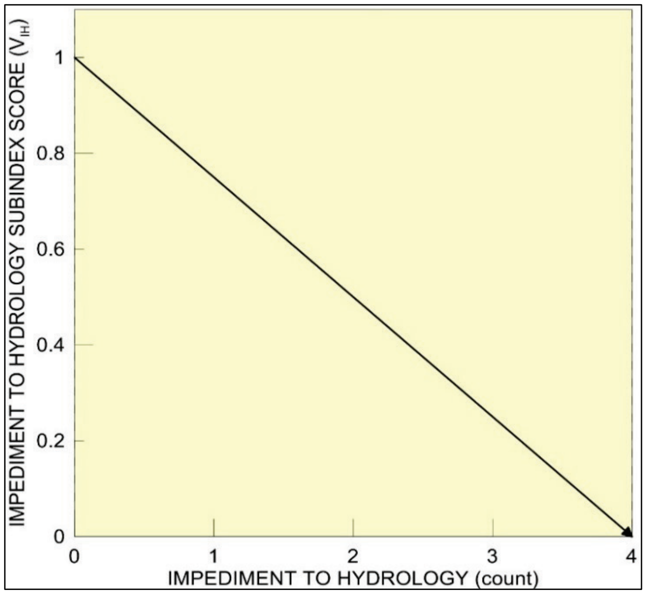
3.1.3 Impediment to hydrology (V_{IH})

V_{IH} is defined as the number of quarter segments assigned in any direction that contain hydrologic impediment, which is caused by the presence of man-made structures, excavations, or fill material. Impediments to hydrology include any activities capable of increasing or decreasing the frequency and duration of surface or near-surface water flow within the assessment area. The structure must have the capacity to impede flow. Other features occurring in a segment that do not impede flow should not be included in the determination of V_{IH}. The example shown in Figure 28 has one quarter segment impaired by a road passing through the northeast quadrant, which correspond to a variable subindex score of 0.75. Use the following procedure to measure V_{IH}:

1. Centered on a representative location within the assessment area, establish an 80 m radius plot.
2. Record the number of quarter segments (0 – 4) that are impeded within the plot.
3. Use Figure 29 or the provided wetland assessment calculator to determine the variable subindex score for V_{IH}.

Figure 28. V_{IH} assessed at the 80 m scale. The shaded segment is impeded by the roadway passing through the plot.

Figure 29. Association between the number of quarter segments within the 80 m radius area that contain an impediment to hydrology value and the V_{IH} variable subindex score.



3.1.4 Evidence of dust deposition (V_{DD})

V_{DD} is defined as the presence of dust deposited from nearby roadways, gravel pads, parking lots, or other disturbed areas on vegetation and/or the ground surface. Dust has the capacity to impact albedo, vegetative communities, local hydrology, and the duration of snow cover (Walker and Everett 1987). Dust is often observed on one side of roadways due to predominant wind direction. Figure 30 displays an area with evidence of dust along a roadway. When present, evidence of dust deposition limits the maximum attainable assessment scores for habitat and biogeochemical cycling to 0.80. Use the following procedure to document V_{DD}:

1. Centered on a representative location within the assessment area, establish an 80 m radius plot.
2. If dust is observed within the area, indicate that on the wetland assessment calculator data form. When present, the deposition of dust limits the maximum attainable assessment subindex scores for habitat and biogeochemical cycling to 0.80.
3. The provided wetland assessment calculator automatically accounts for the adjustment of assessment subindex scores based upon the presence or absence of V_{DD}.

If the source of discoloration is in question, it should be calculated as "disturbance".

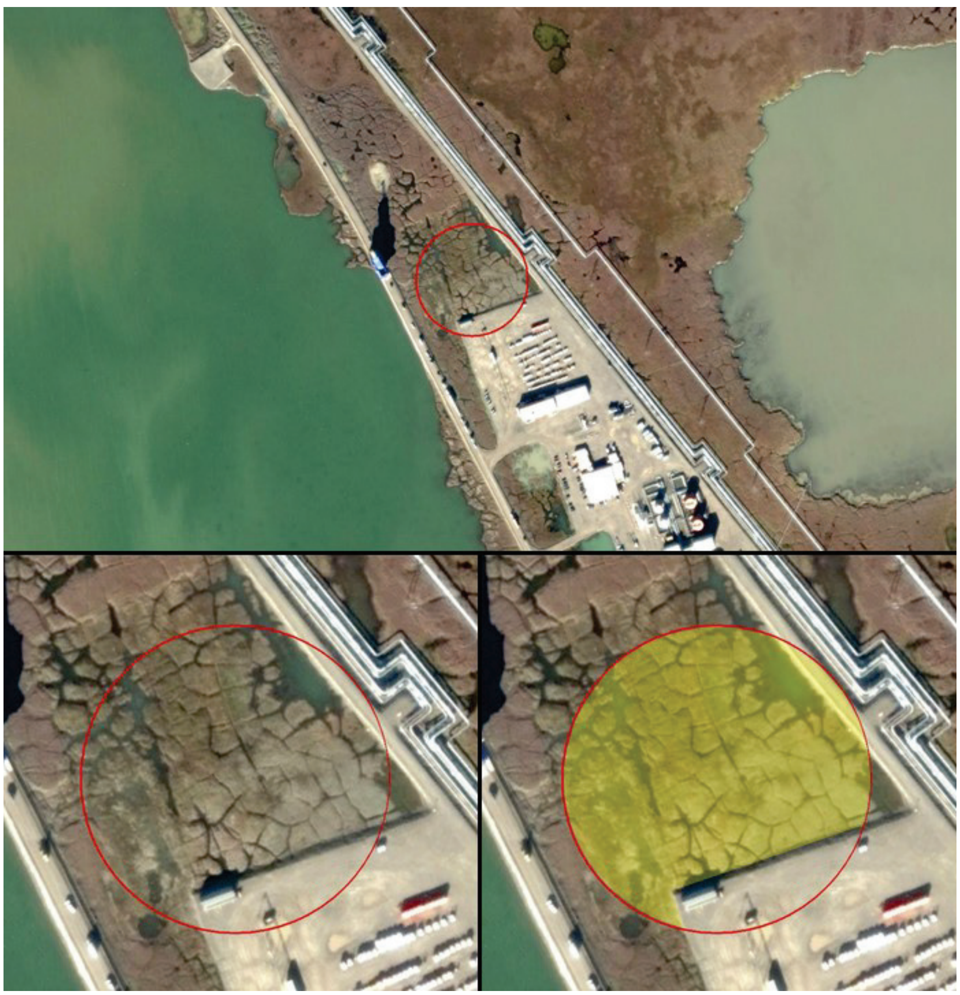
4. If the wetland assessment calculator is not being used, the user must be sure that subindex scores for habitat and biogeochemical cycling do not exceed 0.80.

Figure 30. Evidence of dust deposition adjacent to roadways. Since this variable is assessed as presence or absence, it is not necessary to calculate the area where evidence of dust deposition occurs.

3.1.5 Evidence of thermokarst (V_{TK})

V_{TK} is defined as the presence of thermokarst features within the 80 m radius area, which is often observed adjacent to roadways, gravel pads, or other infrastructure. Figure 31 displays an area with V_{TK} adjacent to a developed area; note the degradation of polygonal ground features and the increase in surface water compared to areas farther from the development site. When present, V_{TK} limits the maximum attainable assessment scores for habitat, hydrology, and biogeochemical cycling to 0.70.

Figure 31. Example of thermokarst features located adjacent to infrastructure; note the patterns of deformed polygonal ground occurring at the edge of fill pads and roads.



Use the following procedure to document V_{TK}:

1. Centered on a representative location within the assessment area, establish an 80 m radius plot.
2. If V_{TK} is observed within the area, indicate that on the wetland assessment calculator data form. When present, thermokarst limits the maximum attainable assessment subindex scores for habitat, hydrology, and biogeochemical cycling to 0.70.
3. The provided wetland assessment calculator automatically accounts for the adjustment of assessment subindex scores based upon the presence or absence of V_{TK}.
4. If the wetland assessment calculator is not being used, the user must be sure that subindex scores for habitat, hydrology, and biogeochemical cycling do not exceed 0.70.

3.1.6 Landscape disturbance (V_{LD})

V_{LD} is defined as the total anthropogenic disturbance, at the landscape scale, quantified as a percentage of an 800 m radius area. Disturbances include, but are not limited to, roads, levees, utility lines, structural features, borrow pits, pads, and parking lots. Potential areas of disturbance that exhibit peculiar coloration and/or textures can be identified using multiple images (e.g., different data sources, historical images, etc.). The example shown in Figure 32 includes a secondary road, borrow pit, and an area of fill deposition (blue) that occupies approximately 12% of the plot, which corresponds to a variable subindex score of 0.76 (Figure 33). Use the following procedure to measure V_{LD}:

1. Centered on a representative location within the assessment area, establish an 800 m radius plot.
2. Determine the total percent of the area occupied by disturbance.
3. Use Figure 33 or the provided wetland assessment calculator to determine the variable subindex score for V_{LD}.

Figure 32. V_{LD} assessed at the 800 m scale, shown in transparent blue.

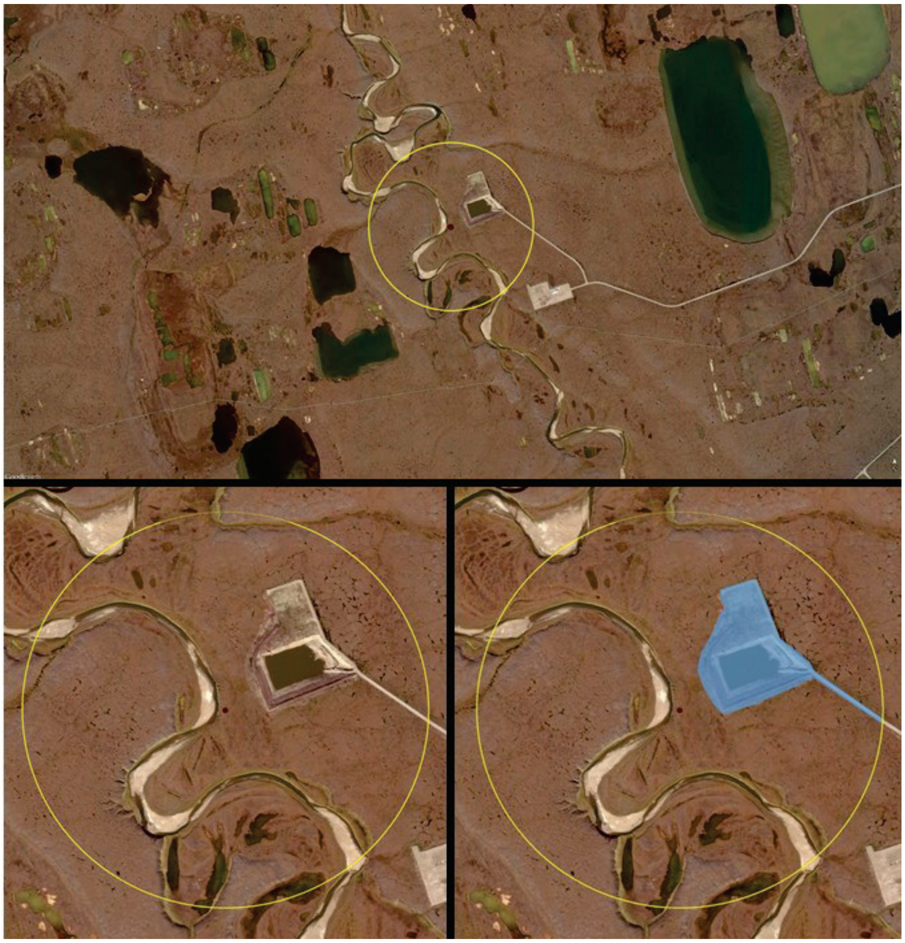
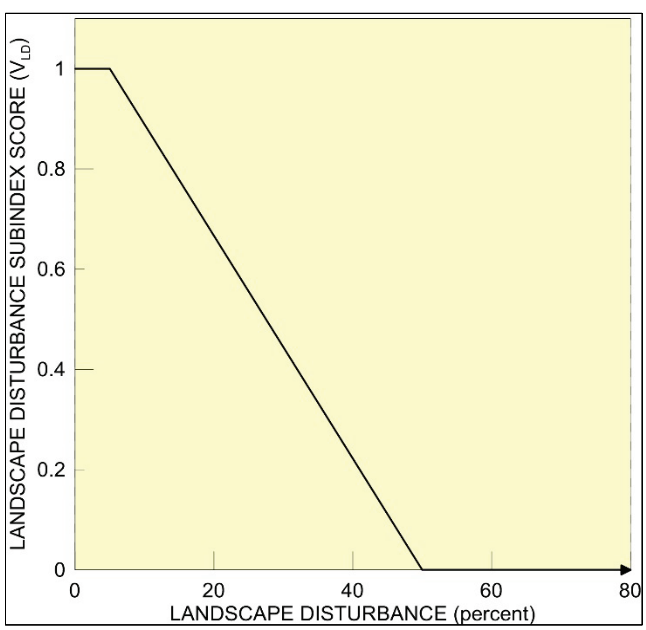


Figure 33. Association between the percentage of the 800 m radius area occupied by disturbance and the V_{LD} variable subindex score.



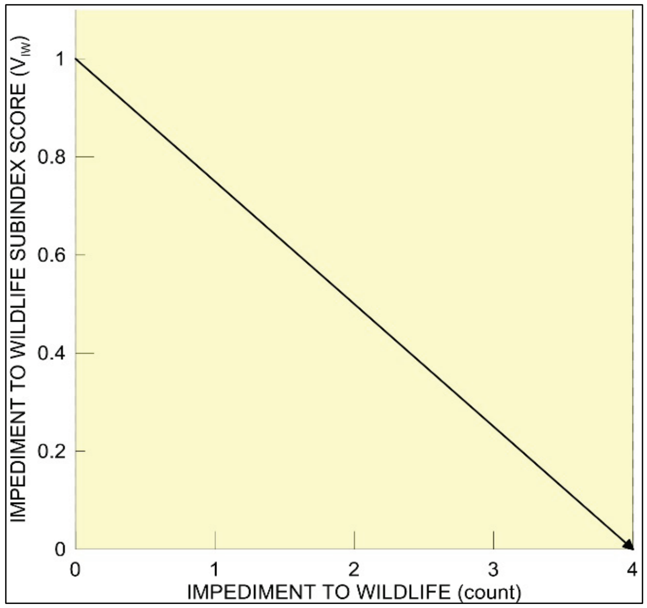
3.1.7 Impediment to wildlife (V_{IW})

V_{IW} is defined as the number of quarter segments, assigned in any direction, that are impaired to the free movement of wildlife by impediments such as roads, pads, pipelines, or other aboveground features. For the purpose of this assessment, natural features (e.g., lakes, rivers) are not considered an impediment. The site shown in Figure 34 has two quarter segments (C and D) that are impaired by an aboveground utility line and associated structure, which correspond at a variable subindex score of 0.5 (Figure 35). Use the following procedure to measure V_{IW}:

1. Centered on a representative location within the assessment area, establish an 800 m radius plot.
2. Count the number of quarter segments (0 – 4) that are impeded within the area.
3. Use Figure 35 or the provided wetland assessment calculator to determine the variable subindex score for V_{IW}.

Figure 34. V_{IW} assessed at the 800 m scale. The shaded segments, C and D, are impeded by aboveground utilities and associated structures.

Figure 35. Association between the number of quarter segments within the 800 m radius area that contain an impediment to wildlife value and the V_{IW} variable subindex score.



3.1.8 Distance to roadway (V_{DR})

V_{DR} is defined as the minimum distance in meters from the center of an 800 m radius area to a roadway of any size, class, or condition. This variable can be measured using the "ruler" tool in Google Earth, the "measure" tool in ArcMap, or a ruler with a map of a known scale. In Figure 36, the nearest roadway is approximately 475 m from the assessment site, and has a subindex score of 0.95 (Figure 37). Use the following procedure to measure V_{DR}:

1. Centered on a representative location within the assessment area, establish an 800 m radius plot.
2. Measure the minimum distance in meters, from the center of the assessment site to the nearest road, up to 800 m.
3. Use Figure 37 or the provided wetland assessment calculator to determine the variable subindex score for V_{DR}.

Figure 36. V_{DR} from the assessment site in meters, at the 800 m scale.

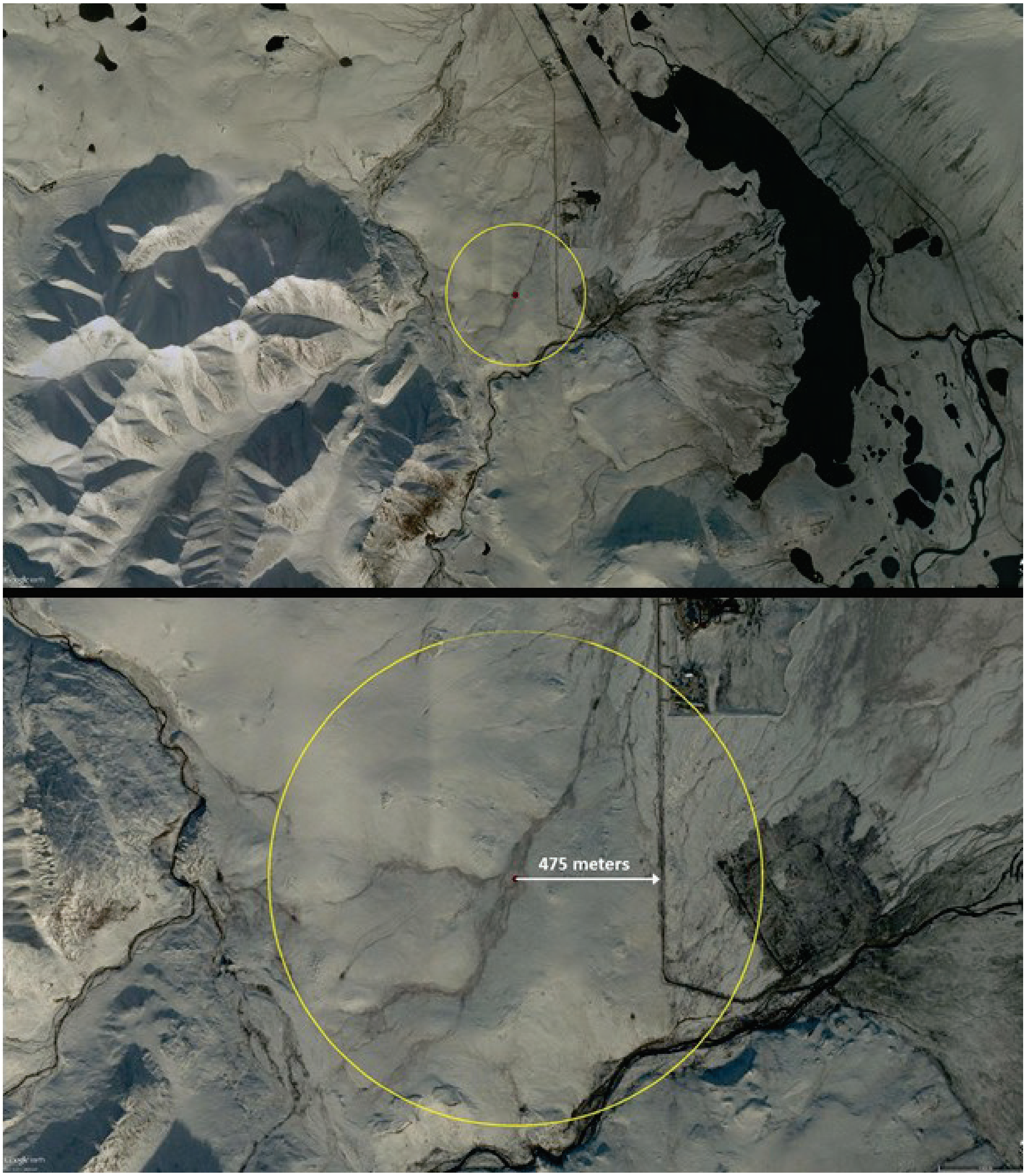
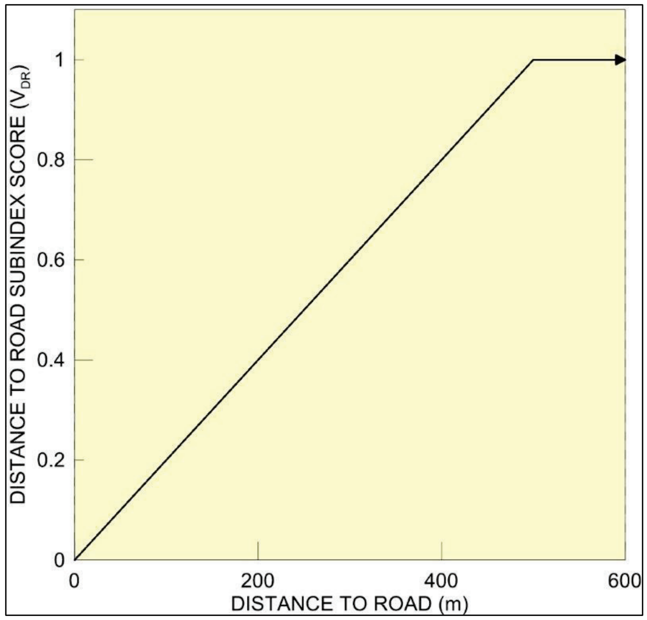


Figure 37. Association between the distance to roadway value and the V_{DR} variable subindex score.



3.2 On-site variable protocol

The collection of on-site variables occurs within the same 80 m radius plot utilized to determine the off-site variables (V_{LLD}, V_{SW}, V_{IH}, V_{TK}, and V_{DD}) above. Procedures for determining each on-site variable are provided below. The variables measurements are converted to a variable subindex score using the figures provided or the wetland assessment calculator.

3.2.1 Microtopography (V_{MT})

V_{MT} is defined as the topographic complexity of the WAA, determined at 1 m intervals along two 30 m transects. Microtopography is an important consideration in many of the wetland types that occur in the tussock tundra and areas exhibiting permafrost features (e.g., ice wedges, polygonal ground). It also serves as an indication of thermokarst and/or signs of wetland degradation. Implement the following procedure to determine V_{MT}:

1. Establish two perpendicular 30 m transects, as shown in Figure 38, within each 80 m radius area utilized during off-site data collection.
2. Orientation of transects should be north to south and east to west, when feasible. Transects should be situated within a particular HGM class (e.g., depression, fringe) to the extent possible. As a result, transect orientations may need to be altered in order to remain within a narrow floodplain

adjacent to small streams. If changes are necessary for plot layout (e.g., due to obstructions or open water, etc.), ensure that established sample plots are representative of the area being sampled, and note any changes to plot layout on the data form.

3. Transects can be established using a laser level and rod or ground stakes and rods, with a level string-line suspended above ground (1–1.5 m above ground level is often adequate). The height of each transect should be sufficient to avoid interference with vegetation (Figure 39).
4. At each 1 m interval along the 30 m transect, a measuring stick is used to record the distance, in centimeters, from the suspended string line or reference level to the ground surface (Figure 40 and 41). Thirty measurements should be recorded on the data form for the transect line.
5. Repeat the procedure for the second transect; thus sixty measurements will be recorded at each sample location.
6. To determine V_{MT}, enter the measured heights at each 1 m interval into the wetland assessment calculator.
7. Alternatively, V_{MT} can be calculated manually by determining the absolute value change between each 1 m interval. For example, in Figure 41 the absolute difference between the first two sample points (60 cm and 75 cm) yield a value of 15. Sum the total change in absolute values for the two transects. The V_{MT} variable subindex score can then be determined using Figures 42–44.

Figure 38. Layout for on-site data collection includes the location of transects (V_{MT}) and quadrats (V_{BG}, V_{SR}). Note that V_{LDD} and V_{LTK} should be documented anywhere within the sample area.

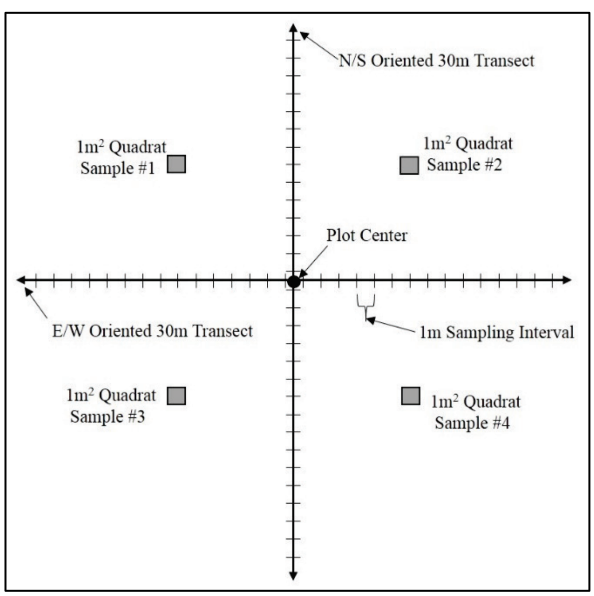


Figure 39. A transect line setup with a level, suspended line for sampling (A), and a close-up of a rod setup for a transect line end (B).

Figure 40. Measuring the distance from the reference level (i.e., level string-line) to the ground surface at each 1 m interval along the transect.

Figure 41. Partial transect line showing elevation difference measurements as measured along 1 m intervals.

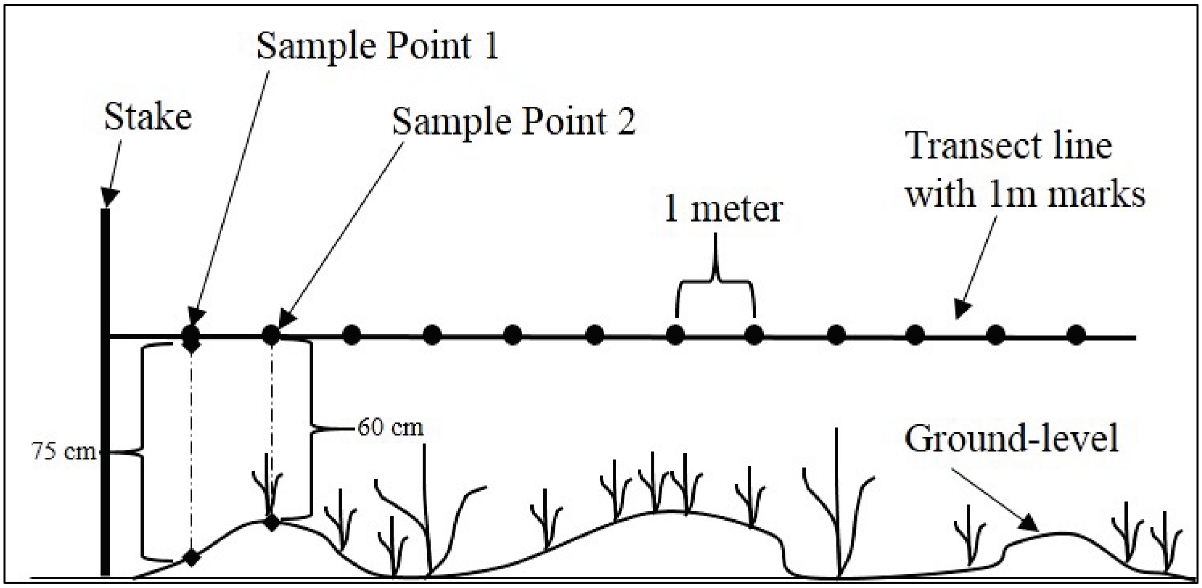


Figure 42. Association between the microtopography value and the V_{MT} variable subindex score for fringe and depression wetland classes.

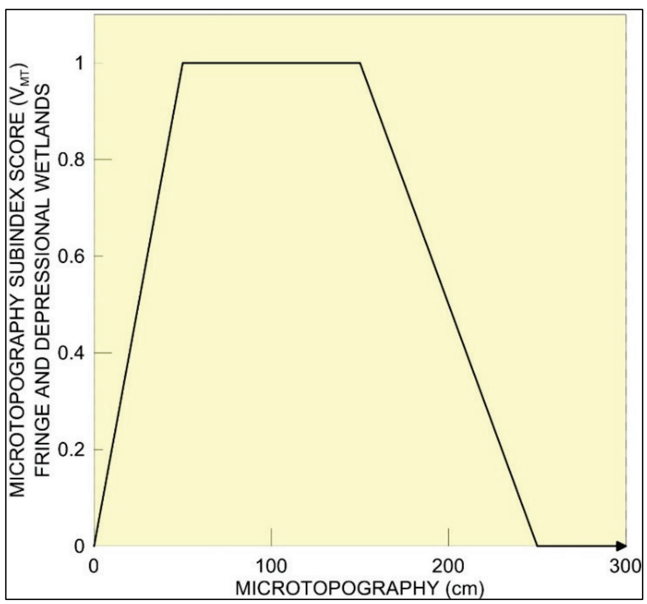


Figure 43. Association between the microtopography value and the V_{MT} variable subindex score for riverine and flats wetland classes.

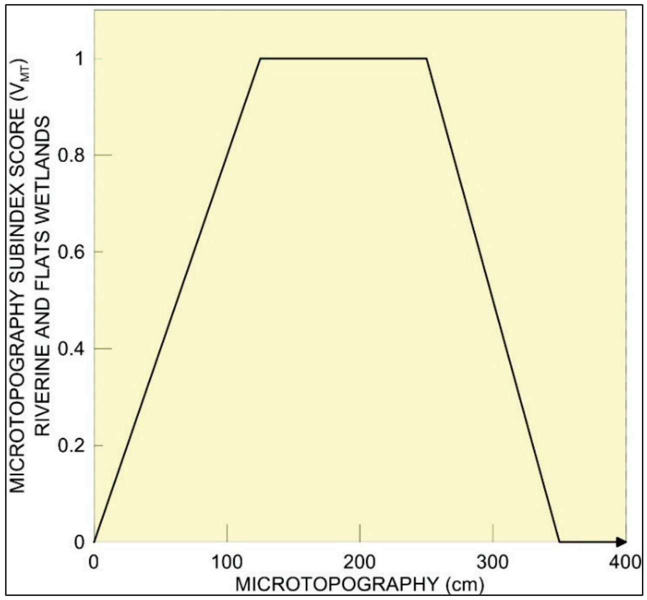
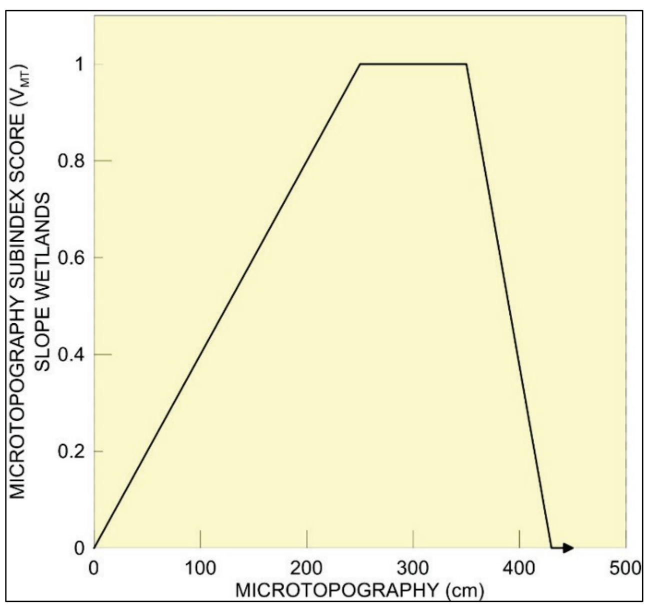


Figure 44. Association between the microtopography value and the V_{MT} variable subindex score for slope wetlands.



3.2.2 Species richness (V_{SR})

V_{SR} is defined as the number of vascular plant species represented within four 1 m² quadrats. V_{SR} provides a rapid assessment tool to evaluate species richness. To determine V_{SR}, use the following protocol:

1. Using the transect lines as boundaries, establish one 1 m^2 quadrat within each quarter segment of the sample area as depicted in Figure 38. Selected quadrat locations should be representative of the site being assessed.
2. Within each quadrat, tally the count of species (vascular plants only; mosses, lichens or liverworts are excluded) and record on the data form.
3. To calculate V_{SR}, the average tally across all four quadrats are used. The calculator tool will calculate V_{SR}, or Figures 45–46 can be used to determine the value. For example, if average species richness within the ACP for a site was four, Figure 45 would be used to determine the V_{SR} subindex score of 0.4. Some wetlands in the region display low species richness regardless of ecological conditions. As a result, wetlands located along tidal fringes and wetlands in which >50% of the total plant cover consists of *Arctophila fulva*, *Carex aquatilis*, and/or *Puccinellia sp*. receive a species richness score of 1.0. The wetland assessment calculator automatically accounts for this based upon user inputs.

Figure 45. Association between the average species richness observed in four 1 m^2 quadrats and the V_{SR} variable subindex score within the ACP region.

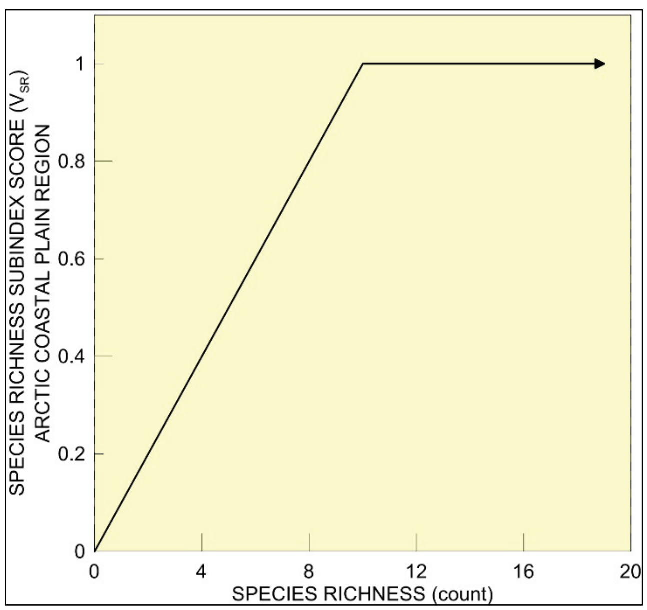
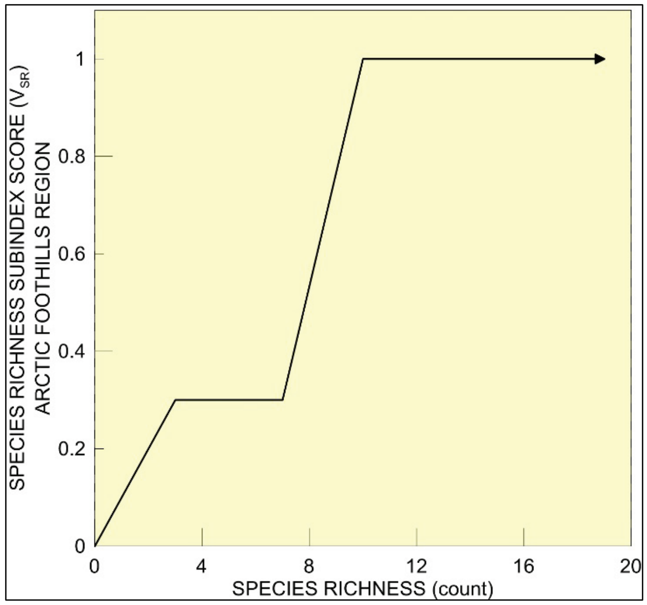


Figure 46. Association between the average species richness observed in four 1 m^2 quadrats and the V_{SR} variable subindex score within the foothills region.



3.2.3 Bare ground (V_{BG})

V_{BG} is defined as a measure of the bare ground and expressed as areas lacking vascular or non-vascular plant cover. V_{BG} is calculated as the average percentage of bare ground observed within four 1 m^2 quadrats. This variable serves as an indirect measure of vegetation density, as areas with low vegetation density display increased levels of bare ground. V_{BG} is calculated using the following protocol:

1. Using the same quadrat sample area used to determine species richness (V_{SR}), estimate the percentage of bare ground to the nearest 5%. Figure 47 provides examples of quadrats with varying amounts of bare ground.
2. The average percentage of bare ground across the four quadrats is used to determine V_{BG}.
3. Use the wetland assessment calculator in Figure 48 to determine the variable subindex score for V_{BG}.

Figure 47. Examples of quadrat with bare ground estimates of (A) 100%, (B) 90%, (C) 25%, and (D) 0%.

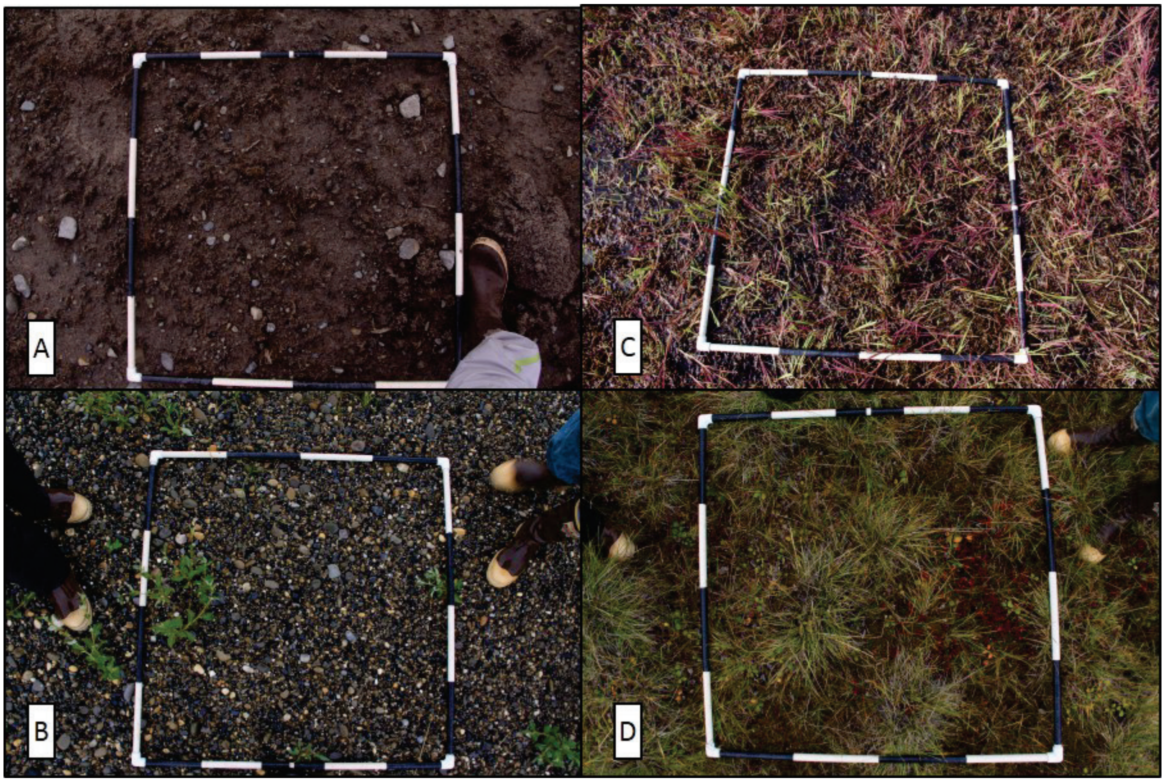
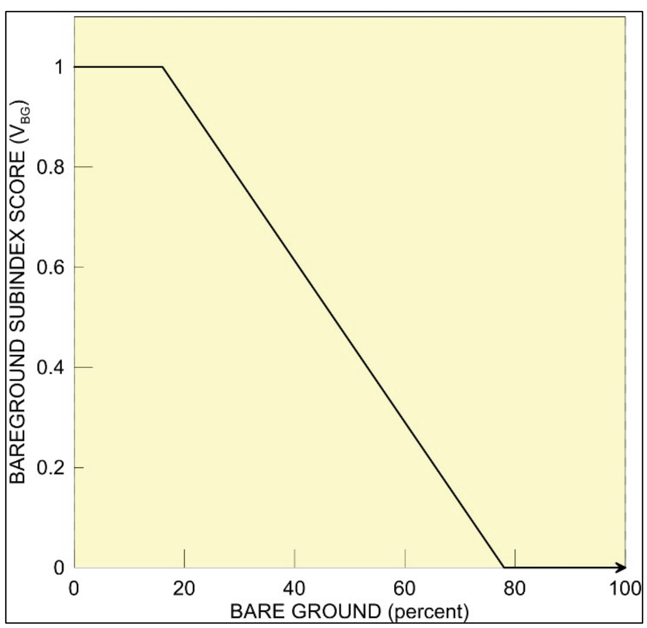


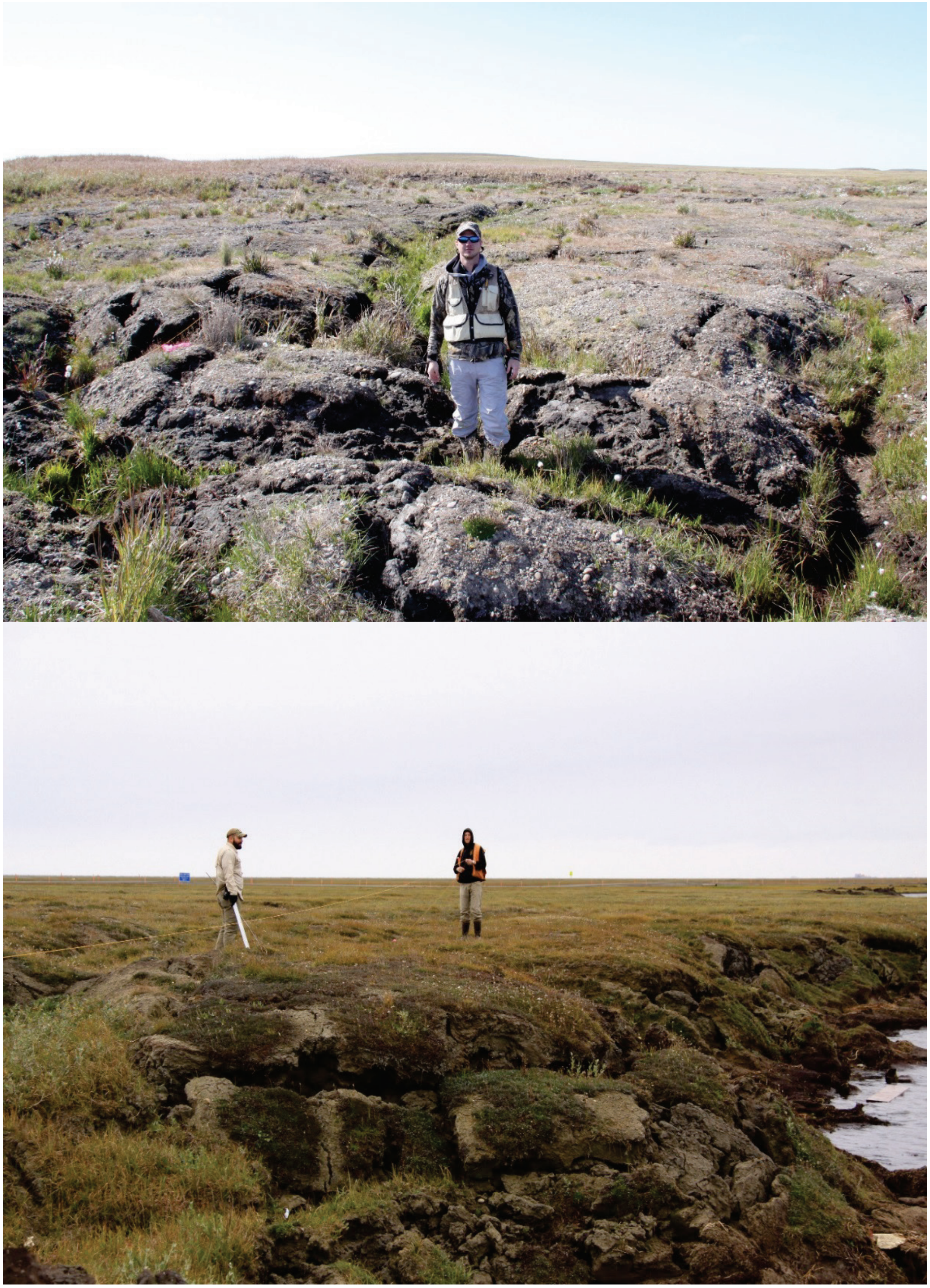
Figure 48. Association between the average percentage of bare ground observed within four 1 m² quadrats and the V_{BG} variable subindex score.



3.2.4 Local evidence of thermokarst (V_{LTK})

If thermokarst disturbance is present on-site, the field team should record it on the data form or select "Yes" if using the calculator tool. When thermokarst occurs within the sampling area, the maximum possible score for the on-site assessment is 0.70. An example of thermokarst is depicted in Figure 49.

Figure 49. Examples of thermokarst occurring in an area where vegetation has been removed (top), and the area adjacent to infrastructure that has formed thermokarst features (bottom).



3.2.5 Local evidence of dust disturbance (V_{LDD})

If dust is present on the vegetation during an on-site assessment as a result of roadway or other disturbance, the field team should record it on the data form or select “Yes” if using the calculator tool. When dust disturbance is present, the maximum possible score for the on-site assessment is 0.80. An example of dust on vegetation at a site is shown in Figure 50.

Figure 50. Examples of dust accumulation on vegetation.

4 Analyze the Data

Analyzing field data can be done manually or automatically using the three-step process outlined below.

1. The first step in analyzing the field data is to transform the field measure of each assessment variable into a variable subindex score on a scale of 0 to 1.0 by using the assessment calculator tool or the figures provided above.
2. The second step is to insert the variable subindices into the assessment equations (Section 2.0) and calculate the assessment scores for hydrology, biogeochemical cycling, habitat, and the on-site modifier (if used):
   a. Habitat assessment score = $[MIN(V_{IW}, V_{DR}) + ((V_{LD} + V_{LLD})/2)]/2$
   b. Hydrology assessment score = $[((V_{IH} + V_{SW})/2)+((V_{LD}+V_{LLD})/2)]^{1/2}$
   c. Biogeochemical cycling assessment score = $MIN(V_{LD}, V_{LLD})$
   d. On-site assessment score modifier = $(V_{SR} + V_{BG} + V_{MT})/3$
3. These assessment scores can then be incorporated into the Alaska District's Credit Debit Methodology (CDM) in order to calculate the credits generated by a mitigation project or the debits incurred by a proposed impact. Examples of how to collect, analyze, and interpret the assessment data are provided in the scenarios in Section 5.0 below.

4.1 Apply assessment results

Once the assessment and analysis phases are complete, the results can be used to compare the WAA at different points in time (e.g., pre- and post-project implementation) or in different WAAs at the same point in time (e.g., comparing project alternatives). To evaluate project-related impacts, at least two assessments will generally be needed. The first determines the assessment score of the WAA in its pre-project state. The second determines the assessment score in a post-project state based on proposed project plans and the anticipated changes to each of the variables. The difference between pre-project and post-project assessment scores represents the potential loss of ecological function due to the project. If the project results in conversion of land from jurisdictional wetlands to uplands, the post-project assessment score will always be 0.

Similarly, in a scenario where establishment, restoration, or enhancement is to be conducted, the difference between the current and future status of

a wetland, represents the potential gain in functional capacity as a result of the mitigation activities. For preservation activities, the potential gain in functional capacity is reflected in the difference between the anticipated assessment score if the project site was preserved (pre-) and the anticipated assessment score if the project site was not preserved (post). However, adjustments for temporal loss and the likelihood of success should be considered. The CDM provides a method to account for these considerations starting with the functional capacity indices described in this guidebook.

5 Scenarios of Proposed Activities

The following section provides scenarios intended to demonstrate application of the wetland assessment and aid users regarding site selection, data interpretation, analysis and application of assessment results. The first scenario examines three alternatives for additional infrastructure installation to an area. The second scenario demonstrates an approach to assessing a linear road expansion project. A third scenario provides an example of how pre- and post-project assessment scores for a proposed preservation-only mitigation project can be evaluated.

5.1 Scenario 1 – Alternatives analysis

The following is an example scenario that demonstrates the evaluation of off-site and on-site variables utilizing the methodology described in this guidebook.

Company XYZ proposed to construct a new well-pad north of an existing facility. The company developed three alternatives (Figures 51 and 52) including: (1) a 6 ha (~15 acre) pad with a 2,816 m long, 6 m wide, access road (blue) in a riverine wetland; (2) a 6 ha (~15 acre) pad with a 1,126 m long, 6 m wide access road (magenta) in a depression wetland; and (3) an 8 ha (~20 acre) pad expansion (orange) in a depression wetland. Each of the alternatives is evaluated using a separate WAA within the project area.

5.1.1 Desktop (Off-site) evaluation of WAA1

WAA1 is located in a riverine wetland. At the 80 m scale (Figure 53), the percent local landscape disturbance (V_{LLD}), percent anthropogenically derived surface water (V_{SW}), impediment to hydrology (V_{IH}), evidence of dust (V_{DD}), and evidence of thermokarst (V_{TK}) are determined. WAA1 contains 0% V_{LLD}, 0% V_{SW}, 0 impeded quarter segments for V_{IH}, and has no visible evidence of dust or thermokarst (i.e., “No” for V_{DD} and V_{TK}).

At the 800 m scale (Figure 54), the percent landscape disturbance (V_{LD}), impediment to wildlife (V_{IW}), and distance to roadway (V_{DR}) are determined. WAA1 contains 0% V_{LD}, as indicated by a linear discolored area, 0 impeded quarter segments for V_{IW}, and the nearest road is located greater than 800 m from WAA1 for V_{DR}. The value for each variable assessed at the 80 m and 800 m scale is used to determine variable subindex scores using the wetland assessment calculator (Figure 55).

Figure 51. Proposed alternative pads with access roads, and pad expansion.

Figure 52. Proposed activities with designated WAAs.

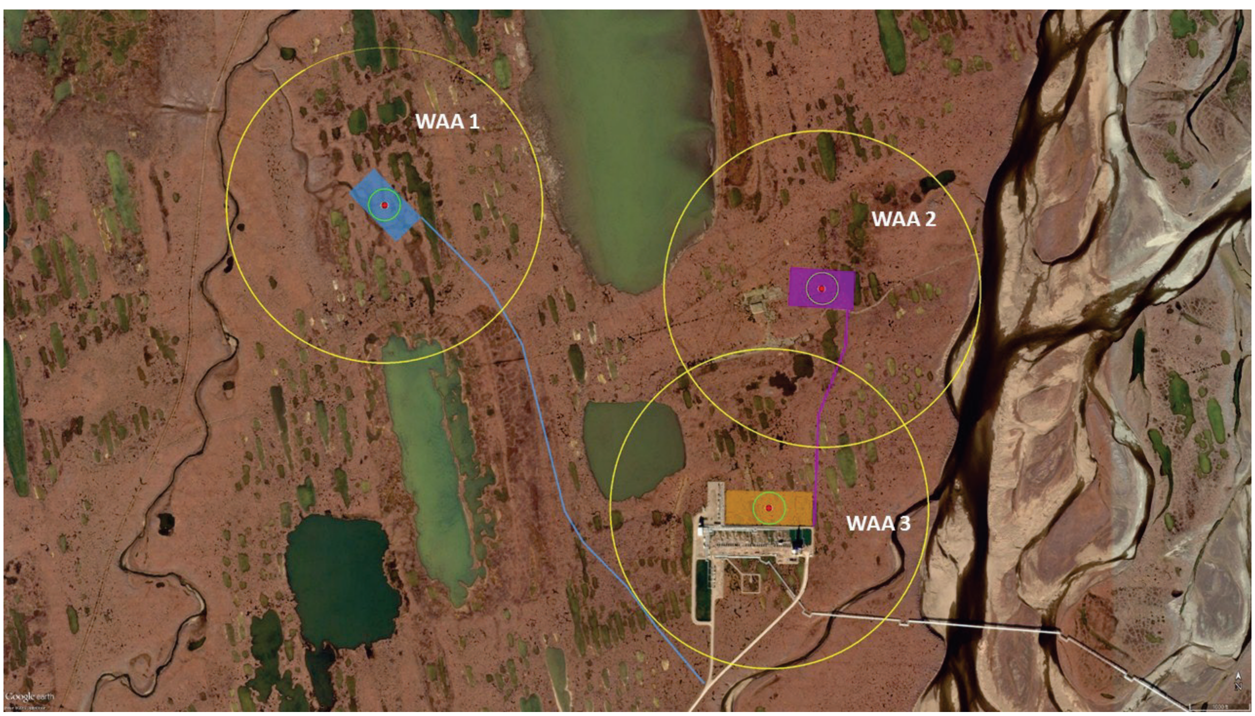


Figure 53. WAA1 at the 80 m scale.

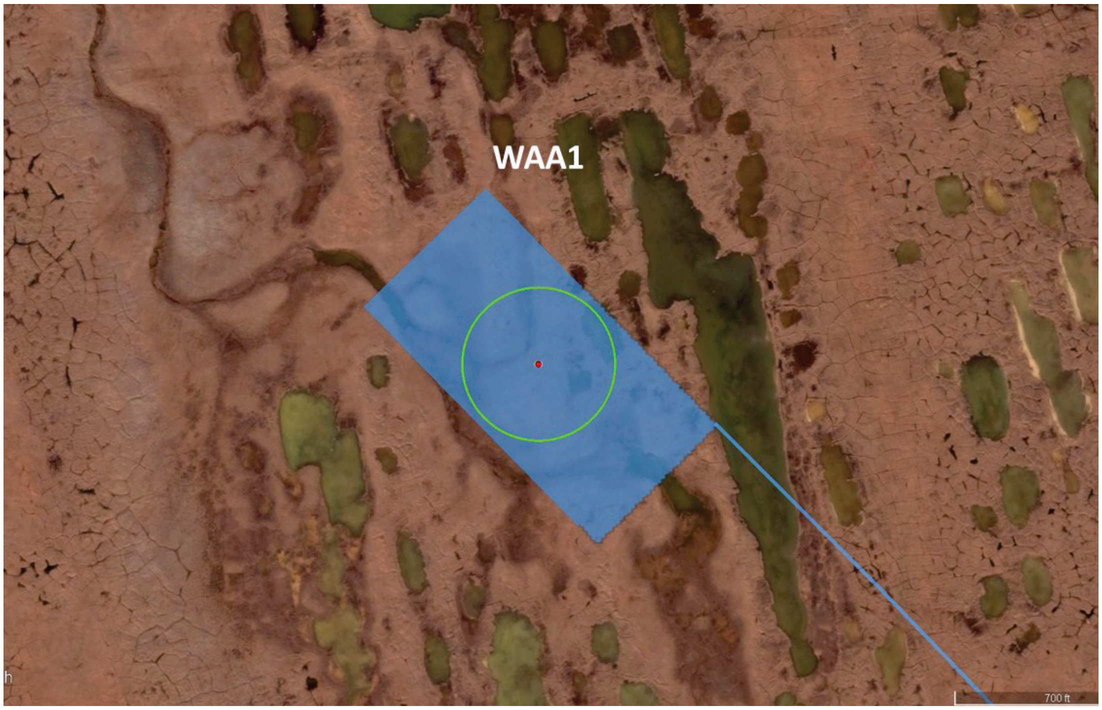


Figure 54. WAA1 at the 800 m scale. A linear discolored area crossing the northern portion of the plot indicates a prior disturbance. This disturbance is less than 1% of the area and, therefore, received a V_{LD} subindex score of 0.

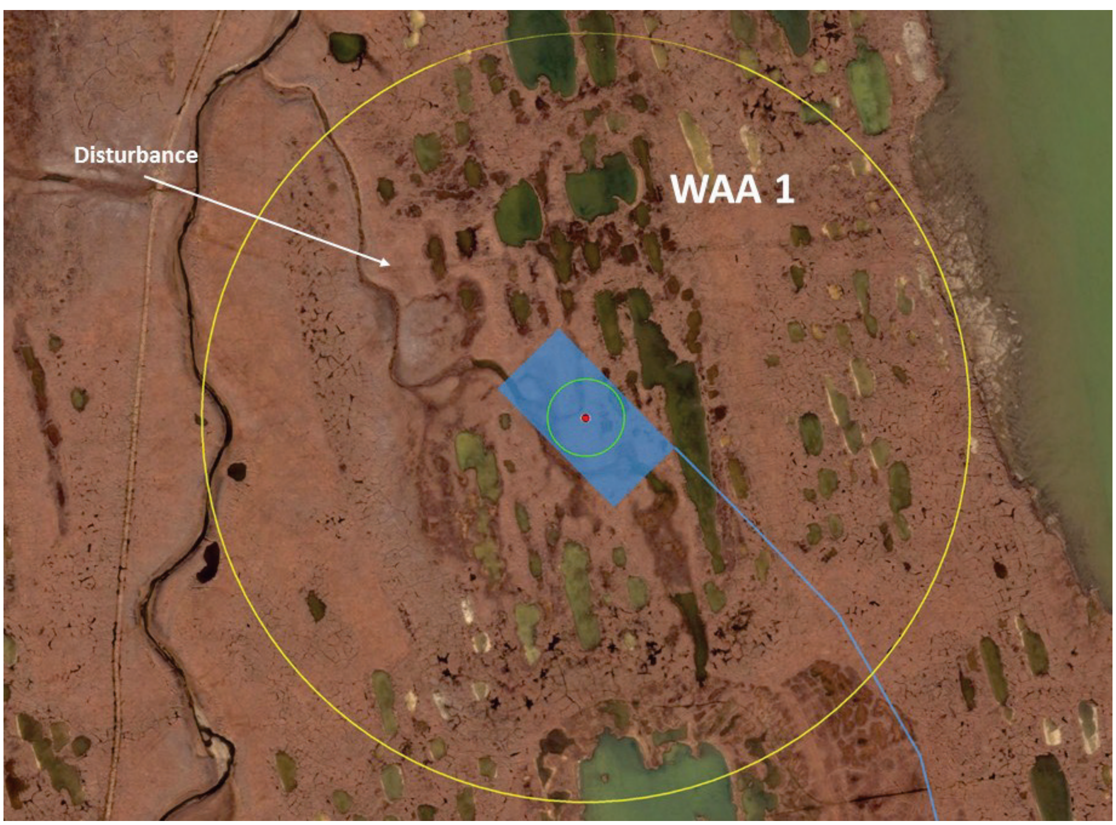


Figure 55. Example of completed off-site assessment for WAA1 using the wetland assessment calculator.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:	WAA1	Latitude/UTM Northing:	XXXX-XXXXX
Date:	8/21/2016	Longitude/UTM Easting:	XXXX-XXXXX
Impact/Mitigation	Impact	Pre/Post	Pre-Project
Region:	Arctic Coastal Plain	Coordinate System:	DATUM 123
HGM Class:	Riverine	Imagery Source (Year):	XYZ flight 6/06/2016
Investigator(s):	John Smith, Jane Smith		

Determine values for variables 1-5 using an 80 meter radius plot.			
1	**V_{LLD}**	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	0
		V_{LLD} Subindex Score	***1.00***
2	**V_{SW}**	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	0
		V_{SW} Subindex Score	***1.00***
3	**V_{IH}**	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	0
		V_{IH} Subindex Score	***1.00***
4	**V_{DD}**	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	No
5	**V_{TK}**	Evidence of Thermokarst	No
Determine values for variables 6-8 using an 800 meter radius plot.			
6	**V_{LD}**	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	0
		V_{LD} Subindex Score	***1.00***
7	**V_{IW}**	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	0
		V_{IW} Subindex Score	***1.00***
8	**V_{DR}**	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	800
		V_{DR} Subindex Score	***1.00***
		Habitat Assessment Score	***1.00***
		Hydrology Assessment Score	***1.00***
		Biogeochemical Cycling Assessment Score	***1.00***

The variable subindex scores are used to calculate the habitat assessment score, hydrology assessment score, and the biogeochemical cycling assessment score.

Habitat Assessment Score

The habitat assessment score is the minimum value of V_{IW} and V_{DR}, plus the sum of V_{LD} and V_{LLD}, divided by two, with the resulting quotient divided by two.

$$\left[MIN\left(V_{IW}, V_{DR}\right) + \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]/2 \rightarrow \left[MIN(1, 1) + \left((1 + 1)/2\right)\right]/2 = 1.0$$

Hydrology Assessment Score

The hydrology assessment score is the sum of V_{IH} and V_{SW}, divided by two, multiplied by the sum of V_{LD} and V_{LLD}, divided by two, with the resulting product raised to the ½ power.

$$\left[\left(\left(V_{IH} + V_{SW}\right)/2\right) X \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]^{1/2} \rightarrow \left[\left((1 + 1)/2\right) X \left((1 + 1)/2\right)\right]^{1/2} = 1.0$$

Biogeochemical Cycling Assessment Score

The biogeochemical cycling assessment score is the minimum value of V_{LD} and V_{LLD}.

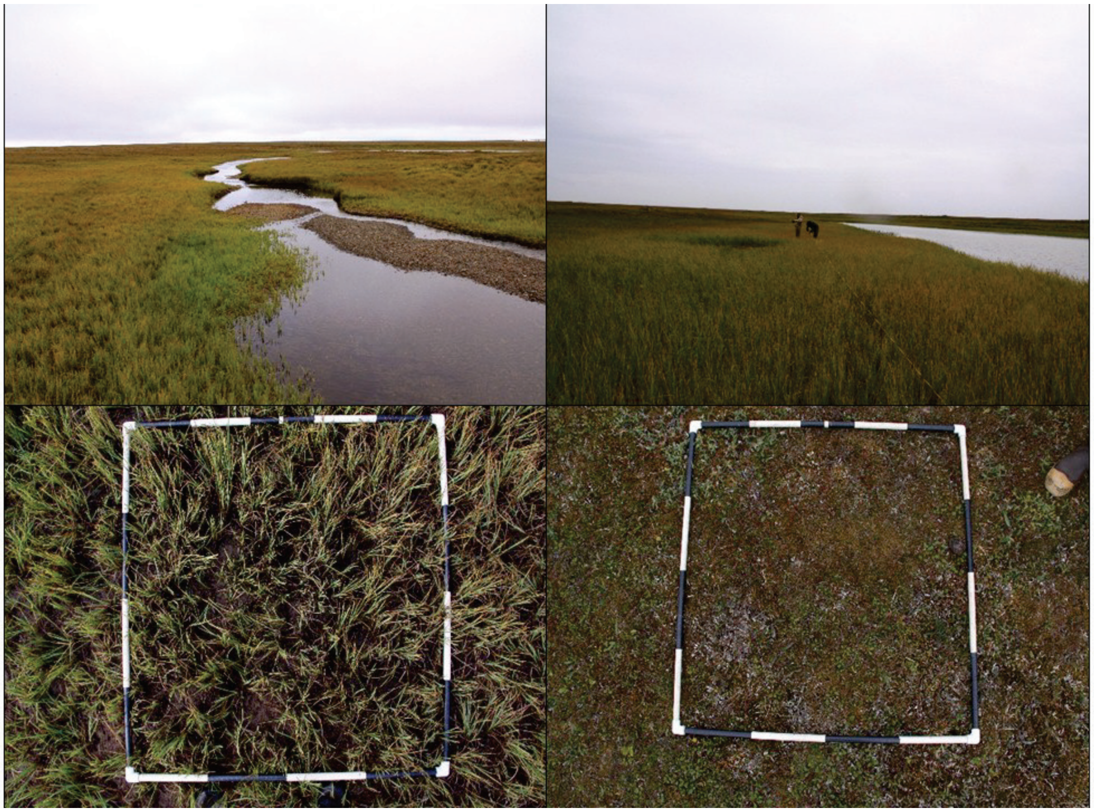
$$MIN\left(V_{LD}, V_{LLD}\right) \rightarrow MIN(1, 1) = 1.0$$

5.1.2 On-site evaluation of WAA1

The on-site evaluation (when utilized) requires the establishment of two 30 m transects and four 1 m^2 quadrats (Figure 56) within the 80 m radius area described above. Each of the on-site variables collected at WAA1 is described below.

V_{MT} is calculated using a measure of absolute change in microtopography across the two transects. At WAA1, the measured microtopography value were entered into the wetland assessment calculator, resulting in an absolute microtopography value of 150. This corresponds to a microtopography variable subindex score (V_{MT}) of 1.0 (Figures 43 and 57).

Figure 56. Demonstrative photos for a site assessment of WAA1 situated within the ACP region.



To calculate V_{SR}, the average species richness of the four quadrat samples is used. In this example, quadrats displayed species richness values of 11, 12, 9, and 8, resulting in an average species richness of 10. The species richness count of 10 in the ACP equates to a V_{SR} variable subindex score of 1.0 (Figures 45 and 57).

To calculate V_{BG}, the average bare ground percentage of the four quadrat samples is used. In this example, the quadrats exhibited bare ground values of 10%, 30%, 15%, and 25%, yielding an average bare ground value of 20%. This equates to a V_{BG} variable subindex score of 0.93 (Figure 48 and 57).

Note that evidence of dust deposition and evidence of thermokarst were both absent from WAA1, and neither were selected on the wetland assessment calculator.

Figure 57. Example of wetland assessment calculator for WAA1 on-site variables.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT

Section B: Onsite Data Collection

Site Name/Location:	WAA1	Latitude/UTM Northing:	XXXX-XXXXX
Sampling Date:	8/21/2016	Longitude/UTM Easting:	XXXX-XXXXX
Arctic Region:	Coastal Plain	Coordinate System:	DATUM 123
HGM Class:	Riverine	Dominant Vegetation:	Carex aquatilis
Field Team:	John Smith, Jane Smith		

Determine values for the following variables:

1 V_{LDD}	Dust presence on vegetation within assessment area?	No
2 V_{LTK}	Thermokarst features within assessment area?	No
3 V_{MT}	Microtopography Sampling using two 30m transects situated in each cardinal direction from established plot center. Establish a level line above vegetation and record distance to ground level at 1m intervals.	

Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)		Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)
1	30	16	24		1	32	16	20
2	21	17	24		2	24	17	20
3	29	18	24		3	23	18	17
4	27	19	25		4	20	19	10
5	27	20	27		5	18	20	24
6	26	21	21		6	19	21	21
7	22	22	20		7	22	22	20
8	19	23	21		8	21	23	18
9	19	24	20		9	17	24	16
10	18	25	21		10	18	25	17
11	20	26	20		11	19	26	15
12	23	27	26		12	16	27	17
13	20	28	30		13	21	28	20
14	19	29	27		14	19	29	24
15	20	30	29		15	19	30	20
			Sum of Microtopography Variability:	***150***			***V_{MT} Subindex Score:***	***1.00***

4 V_{SR}	**Species Richness** tally for vascular plants using 4 randomly assigned 1m^2 quadrats within each quadrant created from transect lines:		
Quadrat 1:	12	Quadrat 3:	9
Quadrat 2:	11	Quadrat 4:	8
Average Species Richness:	***10.00***	***V_{SR} Subindex Score:***	***1.00***
5 V_{BG}	**Bare Ground** percent cover (0-100%) estimates using four randomly assigned 1m^2 quadrats within each transect quadrant:		
Quadrat 1:	10	Quadrat 3:	15
Quadrat 2:	30	Quadrat 4:	25
Average Bare Ground Percentage	***20***	***V_{BG} Subindex Score:***	***0.93***
Site Notes/Remarks:			
		On-Site Assessment Score	***0.98***

The variables subindex scores for V_{SR}, V_{BG}, and V_{MT} are utilized to calculate the on-site assessment score modifier.

On-site Assessment Score Modifier:

$$(V_{SR} + V_{BG} + V_{MT})/3 \rightarrow (1.0 + 0.93 + 1.0)/3 = 0.98$$

A summary of WAA1 assessment outcomes is presented in Table 2 and Figure 58. Summary tables can provide a valuable tool for reporting, documentation, and further analysis at site specific, project level, or regional scales.

Table 2. Summary of wetland assessment scores for WAA1.

Wetland Assessment Component	Assessment Score
Habitat	1.0
Hydrology	1.0
Biogeochemical cycling	1.0
On-site modifier	0.98
Average assessment score	0.99

Thus, the pre-project assessment score for WAA1 is 0.99. If the project results in conversion of land from jurisdictional wetlands to uplands, the post project assessment score will always be zero.

Figure 58. Example of summary of assessment scores for WAA1 generated using the wetland assessment calculator.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT		
Section C: Summary of Assessment Scores		
On-Site Variable Subindex Scores		
V_{MT}	Microtopography	1.00
V_{SR}	Average species richness	1.00
V_{BG}	Average percent bare ground	0.93
V_{LDD}	Local evidence of dust deposition	No
V_{LTK}	Local evidence of thermokarst	No
Off-Site Variable Subindex Scores		
V_{LLD}	Local landscape disturbance	1.00
V_{SW}	Anthropogenically derived surface water	1.00
V_{IH}	Impediment to hydrology	1.00
V_{DD}	Evidence of dust	No
V_{LD}	Landscape disturbance	1.00
V_{IW}	Impediment to wildlife	1.00
V_{DR}	Distance to roadway	1.00
V_{TK}	Evidence of thermokarst	No
Assessment Scores		
	Habitat	*1.00*
	Hydrology	*1.00*
	Biogeochemical	*1.00*
	On-site Modifer	*0.98*
	AVERAGE SCORE	*0.99*

5.1.3 Desktop (Off-site evaluation) of WAA2

WAA2 is located in a depression wetland exhibiting several impacts (Figure 59). WAA2 contains 8% V_{LLD}, 8% V_{SW}, thermokarst (V_{TK}) features are present, and there are 2 impeded quarter segments for V_{IH}. There is no evidence of dust deposition (V_{DD}).

At the 800 m scale (Figure 60), WAA2 contains 8% V_{LD}, 0 impeded quarter segments for V_{IW}, and the nearest roadway is greater than 800 m (V_{DR}). The values for each variable assessed at the 80 m and 800 m scale are used to determine variable subindex scores using the wetland assessment calculator (Figure 61).

Figure 59. WAA2 at the 80 m scale.

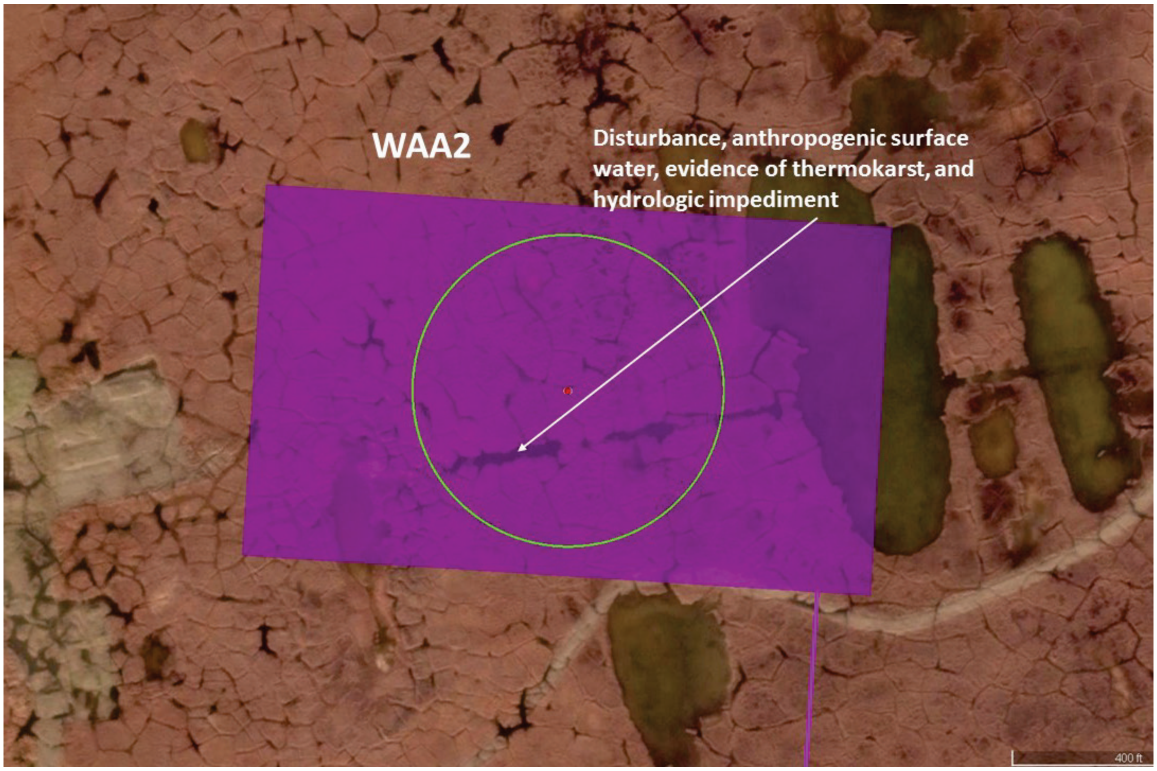


Figure 60. WAA2 at the 800 m scale.

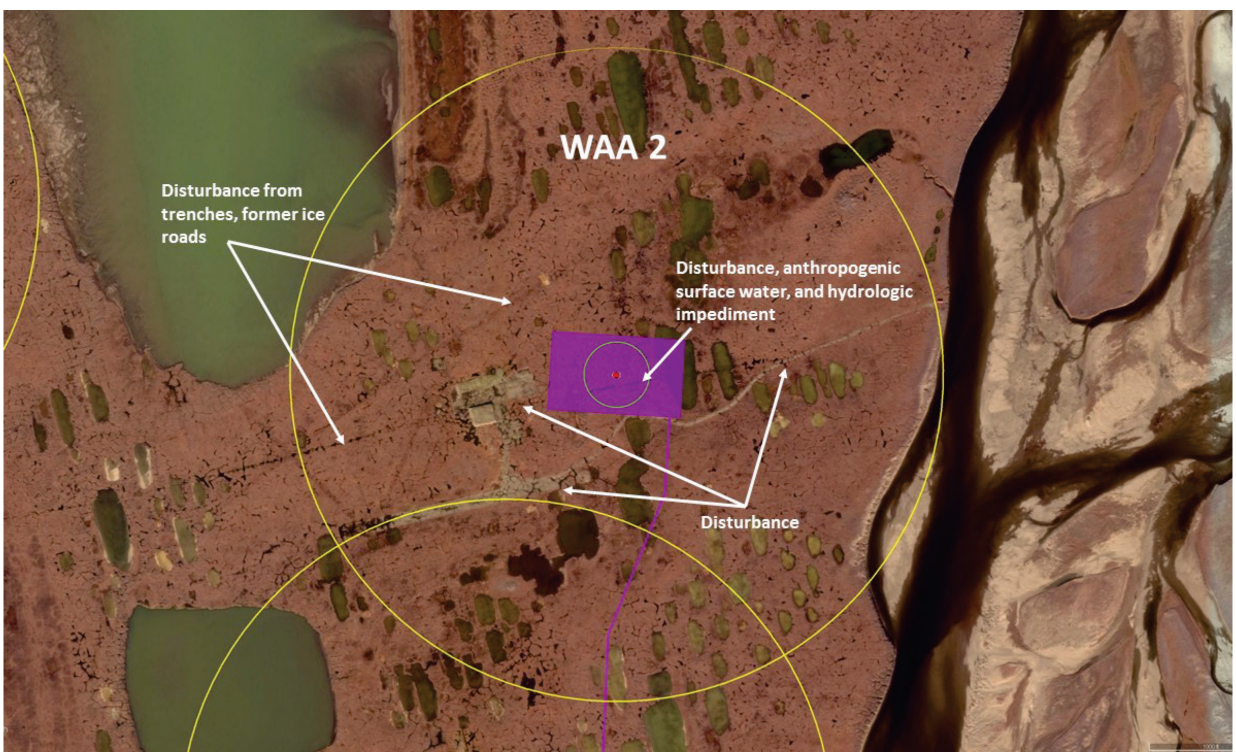


Figure 61. Example of off-site assessment scores for WAA2.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:	WAA2	Latitude/UTM Northing:	XXXX-XXXXX
Date:	8/21/2016	Longitude/UTM Easting:	XXXX-XXXXX
Impact/Mitigation	Impact	Pre/Post	Pre-Project
Region:	Arctic Coastal Plain	Coordinate System:	DATUM 123
HGM Class:	Depression	Imagery Source (Year):	XYZ flight 6/06/2016
Investigator(s):	John Smith, Jane Smith		

Determine values for variables 1-5 using an 80 meter radius plot.			
1	**V_{LLD}**	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	8
		***V_{LLD}* Subindex Score**	***0.80***
2	**V_{SW}**	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	8
		***V_{SW}* Subindex Score**	***0.50***
3	**V_{IH}**	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	2
		***V_{IH}* Subindex Score**	***0.50***
4	**V_{DD}**	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	No
5	**V_{TK}**	Evidence of Thermokarst	Yes
Determine values for variables 6-8 using an 800 meter radius plot.			
6	**V_{LD}**	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	8
		***V_{LD}* Subindex Score**	***0.93***
7	**V_{IW}**	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	0
		***V_{IW}* Subindex Score**	***1.00***
8	**V_{DR}**	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	800
		***V_{DR}* Subindex Score**	***1.00***
		Habitat Assessment Score	***0.70***
		Hydrology Assessment Score	***0.66***
		Biogeochemical Cycling Assessment Score	***0.70***

The variable subindex scores are used to calculate the habitat assessment score, hydrology assessment score, and the biogeochemical cycling assessment score.

Habitat Assessment Score:

$$\left[MIN\left(V_{IW},\, V_{DR}\right) + \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]/2 \rightarrow \left[MIN\left(1,\, 1\right) + \left(\left(0.93 + 0.80\right)/2\right)\right]/2 = 0.70$$

Hydrology Assessment Score:

$$\left[\left(\left(V_{IH} + V_{SW}\right)/2\right) X \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]^{1/2} \rightarrow \left[\left(\left(0.5 + 0.5\right)/2\right) X \left(\left(0.93 + 0.80\right)/2\right)\right]^{1/2} = 0.66$$

Biogeochemical Cycling Assessment Score:

$$MIN\left(V_{LD},\, V_{LLD}\right) \rightarrow MIN\left(0.93,\, 0.80\right) = 0.70$$

5.1.4 On-site evaluation of WAA2

The WAA2 variable subindex scores for V_{SR}, V_{BG}, and V_{MT}, are used to calculate the on-site assessment score modifier (Figures 62 and 63). The measured microtopography values were entered into the wetland assessment calculator, which yielded in an absolute microtopography value of 40, which corresponds to a microtopography variable subindex score (V_{MT}) of 0.80 (Figures 43 and 63). Quadrats displayed species richness values of 3, 2, 3, and 1, resulting in an average species richness of 2.25. An average species richness of 2.25 in the ACP equates to a V_{SR} variable subindex score of 0.23. Because the site is dominated (i.e., >50% of vegetative cover) by *Arctophila fulva*, which naturally occurs in near monotypic stands, the V_{SR} variable subindex score is automatically adjusted to 1.0 (Figures 44 and 63). The percentage of bare ground in the four quadrats was determined to be 40%, 30%, 35%, and 55%. The average bare ground percentage of 40% equates to a V_{BG} score of 0.61 (Figure 63). No thermokarst or dust deposition was identified within the on-site assessment area.

The variables subindex scores for V_{SR}, V_{BG}, and V_{MT} are utilized to calculate the on-site assessment score modifier (Figure 64).

On-site Assessment Score Modifier:

$$\left(V_{SR} + V_{BG} + V_{MT}\right)/3 \rightarrow \left(1.0 + 0.61 + 0.8\right)/3 = 0.80$$

Thus, the pre-project assessment score for WAA2 is 0.72. If the project results in conversion of land from jurisdictional wetlands to uplands, the post project assessment score will always be zero.

Figure 62. On-site photos for WAA2 situated within the ACP, note the dominance of *Arctophila fulva,* which results in a species richness variable subindex score of 1.0.

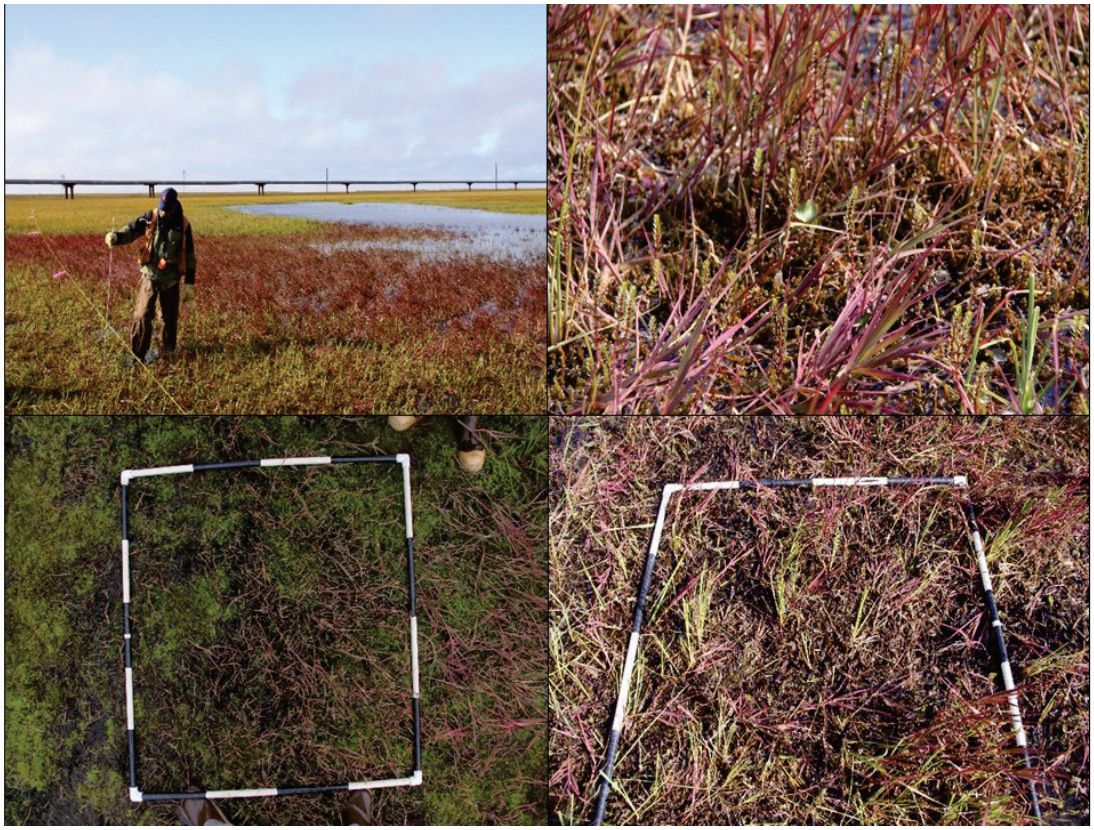


Figure 63. Example of on-site data for WAA2, which was determined by using the wetland assessment calculator.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section B: Onsite Data Collection			
Site Name/Location:	WAA2	Latitude/UTM Northing:	XXXX-XXXXX
Sampling Date:	8/21/2016	Longitude/UTM Easting:	XXXX-XXXXX
Region:	Arctic Coastal Plain	Coordinate System:	DATUM 123
HGM Class:	Depression	Dominant Vegetation:	Arctophila fulva
Field Team:	John Smith, Jane Smith		

Determine values for the following variables:

1	V_{LDD}	Dust presence on vegetation within assessment area?	No
2	V_{LTK}	Thermokarst features within assessment area?	No
3	V_{MT}	Microtopography Sampling using two 30m transects situated in each cardinal direction from established plot center. Establish a level line above vegetation and record distance to ground level at 1m intervals.	

Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)
1	28	16	29	1	21	16	24
2	31	17	29	2	21	17	24
3	31	18	30	3	21	18	24
4	31	19	30	4	23	19	23
5	32	20	30	5	22	20	24
6	32	21	28	6	23	21	25
7	32	22	29	7	25	22	24
8	29	23	27	8	26	23	24
9	30	24	29	9	26	24	24
10	30	25	29	10	28	25	23
11	29	26	29	11	28	26	23
12	29	27	28	12	28	27	23
13	30	28	28	13	27	28	22
14	30	29	25	14	25	29	22
15	30	30	25	15	25	30	22

Sum of Microtopography Variability:	*40*	*V_{MT} Subindex Score:*	*0.80*

4 V_{SR} — **Species Richness** tally for vascular plants using 4 randomly assigned 1m^2 quadrats within each quadrant created from transect lines:

Quadrat 1:	3	Quadrat 3:	3
Quadrat 2:	2	Quadrat 4:	1
Average Species Richness:	*2.25*	*V_{SR} Subindex Score:*	*1.00*

5 V_{BG} — **Bare Ground** percent cover (0-100%) estimates using four randomly assigned 1m^2 quadrats within each transect quadrant:

Quadrat 1:	40	Quadrat 3:	35
Quadrat 2:	30	Quadrat 4:	55
Average Bare Ground Percentage	*40*	*V_{BG} Subindex Score:*	*0.61*

Site Notes/Remarks:

On-Site Assessment Score	*0.80*

Figure 64. Example of summary of assessment scores for WAA2, which was generated using the wetland assessment calculator.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT		
Section C: Summary of Assessment Scores		
On-Site Variable Subindex Scores		
V_{MT}	Microtopography	0.80
V_{SR}	Average species richness	1.00
V_{BG}	Average percent bare ground	0.61
V_{LDD}	Local evidence of dust deposition	No
V_{LTK}	Local evidence of thermokarst	No
Off-Site Variable Subindex Scores		
V_{LLD}	Local landscape disturbance	0.80
V_{SW}	Anthropogenically derived surface water	0.50
V_{IH}	Impediment to hydrology	0.50
V_{DD}	Evidence of dust	No
V_{LD}	Landscape disturbance	0.93
V_{IW}	Impediment to wildlife	1.00
V_{DR}	Distance to roadway	1.00
V_{TK}	Evidence of thermokarst	Yes
Assessment Scores		
	Habitat	*0.70*
	Hydrology	*0.66*
	Biogeochemical	*0.70*
	On-site Modifer	*0.80*
	AVERAGE SCORE	*0.72*

5.1.5 Desktop (Off-site) evaluation of WAA3

WAA3 is located in a depression wetland area immediately adjacent to existing infrastructure (Figure 65). WAA3 contains 15% V_{LLD}, 10% V_{SW}, some thermokarst (V_{TK}) features, 2 impeded quarter segments for V_{IH}, and no visible evidence of dust (V_{DD}). Because evidence of thermokarst (V_{TK}) is present, the three assessment component scores are limited to a maximum of 0.70.

At the 800 m scale (Figure 66), WAA3 contains 20% V_{LD}, 3 impeded quarter segments for V_{IW} (shaded portion), and is 52 m from the nearest roadway (V_{DR}). The value for each variable assessed at the 80 m and 800 m scale is used to determine variable subindex scores using the wetland assessment calculator (Figure 67).

Figure 65. WAA3 at the 80 m scale.

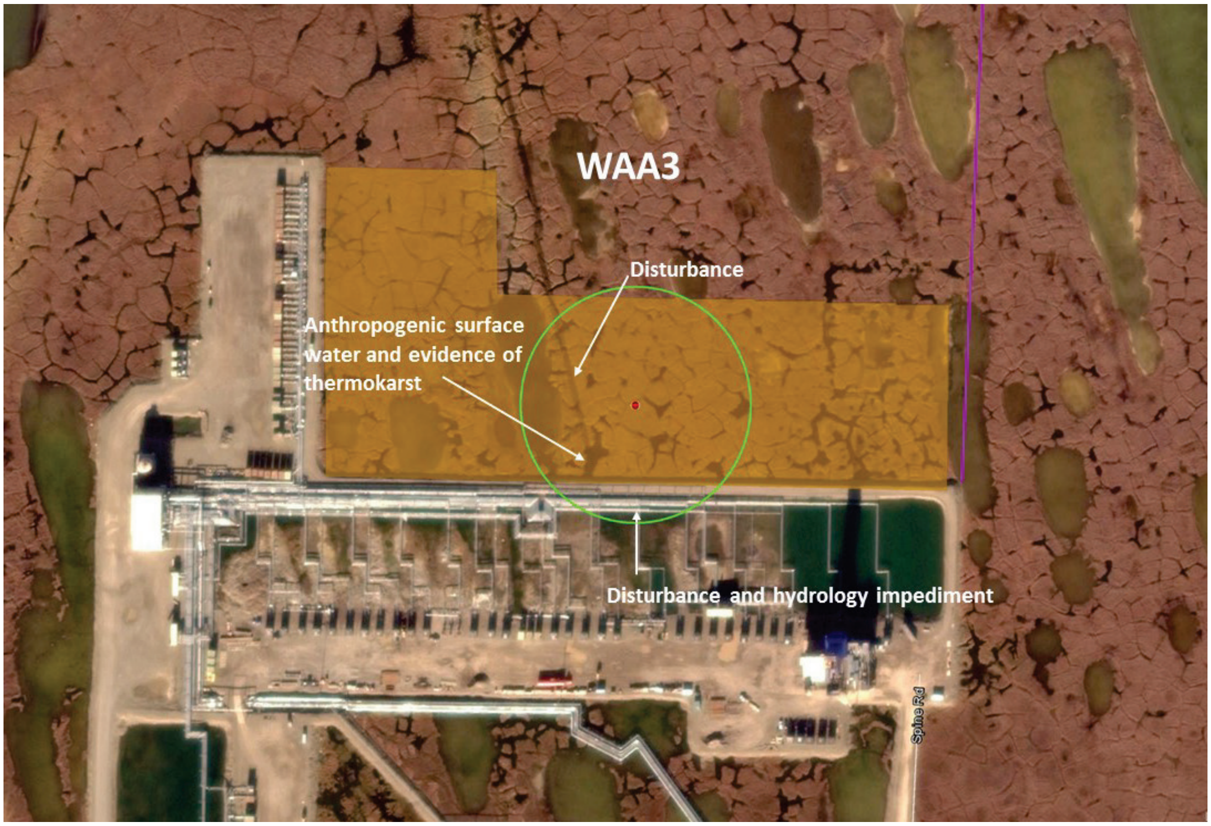


Figure 66. WAA3 at the 800 m scale. Shaded portion of the plot is impeded to wildlife movement.

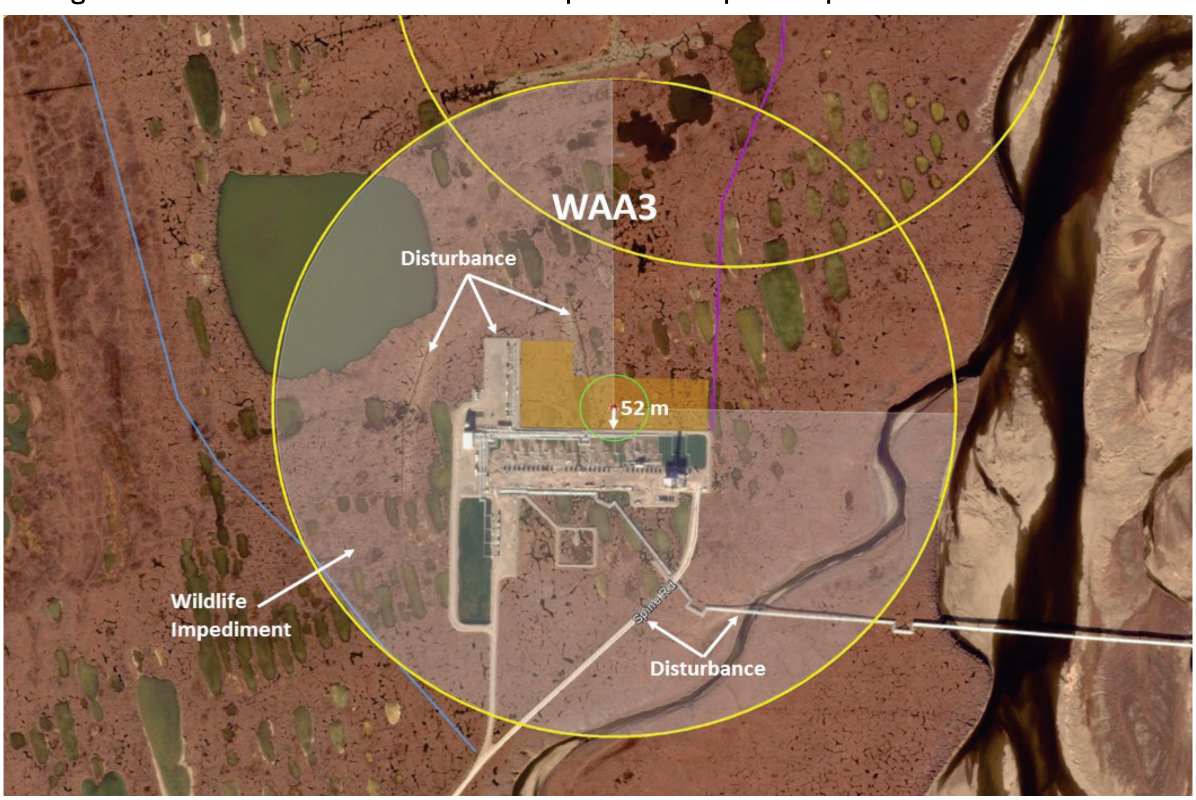


Figure 67. Example of wetland assessment calculator used to determine off-site scores for WAA3.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:	WAA3	Latitude/UTM Northing:	XXXX-XXXXX
Date:	8/21/2016	Longitude/UTM Easting:	XXXX-XXXXX
Impact/Mitigation	Impact	Pre/Post	Pre-Project
Region:	Arctic Coastal Plain	Coordinate System:	DATUM 123
HGM Class:	Depression	Imagery Source (Year):	XYZ flight 6/06/2016
Investigator(s):	John Smith, Jane Smith		

Determine values for variables 1-5 using an 80 meter radius plot.			
1	V_{LLD}	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	15
		V_{LLD} Subindex Score	***0.63***
2	V_{SW}	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	10
		V_{SW} Subindex Score	***0.38***
3	V_{IH}	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	2
		V_{IH} Subindex Score	***0.50***
4	V_{DD}	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	No
5	V_{TK}	Evidence of Thermokarst	Yes
Determine values for variables 6-8 using an 800 meter radius plot.			
6	V_{LD}	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	20
		V_{LD} Subindex Score	***0.67***
7	V_{IW}	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	3
		V_{IW} Subindex Score	***0.25***
8	V_{DR}	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	52
		V_{DR} Subindex Score	***0.10***
		Habitat Assessment Score	***0.38***
		Hydrology Assessment Score	***0.53***
		Biogeochemical Cycling Assessment Score	***0.63***

The variable subindex scores are used to calculate the habitat assessment score, hydrology assessment score, and the biogeochemical cycling assessment score.

Habitat Assessment Score

$$\left[MIN\left(V_{IW}, V_{DR}\right) + \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]/2 \rightarrow \left[MIN\left(0.25, 0.1\right) + \left(\left(0.67 + 0.63\right)/2\right)\right]/2 = 0.38$$

Hydrology Assessment Score

$$\left[\left(\left(V_{IH} + V_{SW}\right)/2\right) X \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]^{1/2} \rightarrow \left[\left(\left(0.5 + 0.38\right)/2\right) X \left(\left(0.67 + 0.63\right)/2\right)\right]^{1/2} = 0.53$$

Biogeochemical Cycling Assessment Score

The biogeochemical cycling assessment score is the minimum value of V_{LD} and V_{LLD}.

$$MIN\left(V_{LD}, V_{LLD}\right) \rightarrow MIN\left(0.67, 0.63\right) = 0.63$$

5.1.6 On-site evaluation of WAA3

The WAA3 variable subindex scores for V_{SR}, V_{BG}, and V_{MT} are used to calculate the on-site assessment score modifier (Figures 68 and 69). Local evidence of thermokarst was observed at the sample location, limiting wetland assessment scores to a maximum value of 0.70.

Figure 68. Demonstrative photos for on-site assessment of WAA3 situated within the ACP and directly adjacent to a gravel pad.

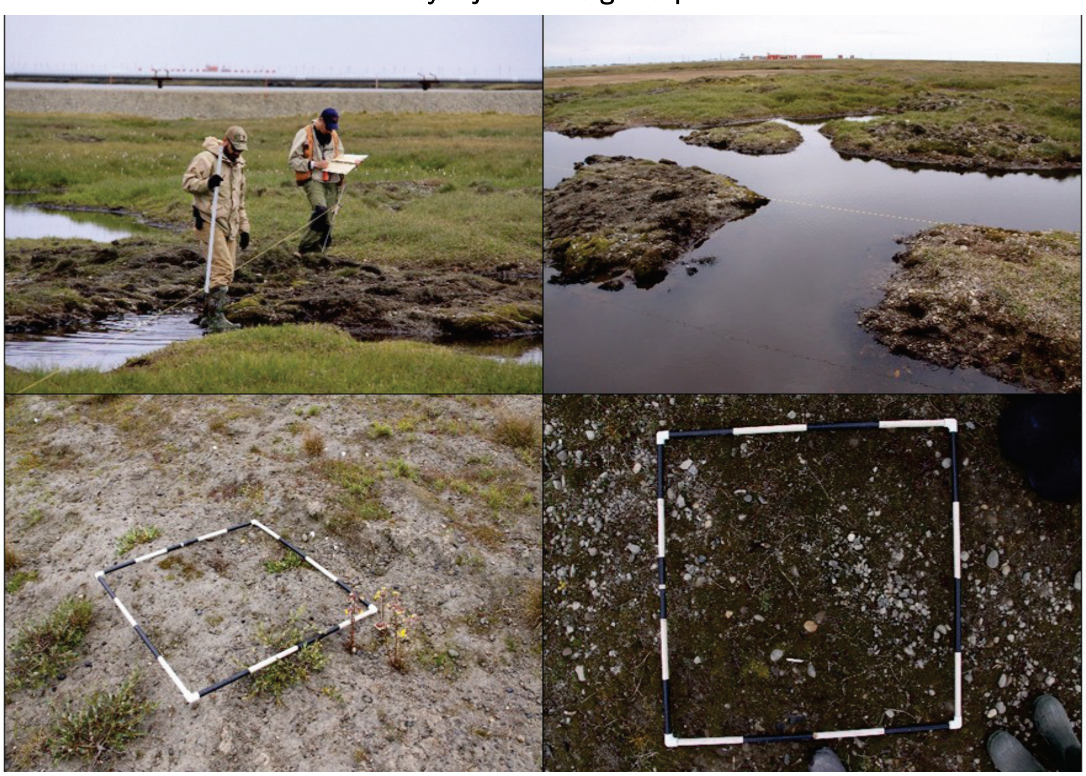


Figure 69. Example of on-site wetland assessment scores, which were determined by using the wetland assessment calculator.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT

Section B: Onsite Data Collection

Site Name/Location:	WAA3	Latitude/UTM Northing:	XXXX-XXXXX
Sampling Date:	8/21/2016	Longitude/UTM Easting:	XXXX-XXXXX
Arctic Region:	Coastal Plain	Coordinate System:	DATUM 123
HGM Class:	Depression	Dominant Vegetation:	Other...
Field Team:	John Smith, Jane Smith		

Determine values for the following variables:

1 V_{LDD}	Dust presence on vegetation within assessment area?	No
2 V_{LTK}	Thermokarst features within assessment area?	Yes
3 V_{MT}	Microtopography Sampling using two 30m transects situated in each cardinal direction from established plot center. Establish a level line above vegetation and record distance to ground level at 1m intervals.	

Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)		Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)
1	29	16	25		1	30	16	30
2	20	17	26		2	18	17	32
3	24	18	25		3	18	18	35
4	27	19	24		4	27	19	32
5	28	20	23		5	28	20	32
6	26	21	21		6	28	21	28
7	28	22	17		7	27	22	30
8	29	23	19		8	25	23	35
9	14	24	13		9	27	24	30
10	27	25	10		10	28	25	28
11	28	26	22		11	27	26	24
12	27	27	19		12	30	27	20
13	27	28	13		13	30	28	21
14	27	29	21		14	29	29	24
15	26	30	30		15	28	30	23
Sum of Microtopography Variability:				185	*V_{MT} Subindex Score:*			0.43

4 V_{SR}	**Species Richness** tally for vascular plants using 4 randomly assigned 1m^2 quadrats within each quadrant created from transect lines:			
Quadrat 1:	7		Quadrat 3:	5
Quadrat 2:	5		Quadrat 4:	7
Average Species Richness:	6.00		*V_{SR} Subindex Score:*	0.60
5 V_{BG}	**Bare Ground** percent cover (0-100%) estimates using four randomly assigned 1m^2 quadrats within each transect quadrant:			
Quadrat 1:	40		Quadrat 3:	65
Quadrat 2:	80		Quadrat 4:	55
Average Bare Ground Percentage	60		*V_{BG} Subindex Score:*	0.29
Site Notes/Remarks:				
			On-Site Assessment Score	0.44

At WAA3, the measured microtopography values were entered into the wetland assessment calculator, resulting in an absolute microtopography value of 185. This is an example of the development of unusually uneven surfaces. The result corresponds to a microtopography variable subindex score (V_{MT}) of 0.43 (Figures 44 and 69). In this example, quadrats displayed species richness values of 7, 5, 5, and 7 respectively, resulting in an average species richness of 6. The species richness count of 6 in the ACP equates to a V_{SR} variable subindex score of 0.60 (Figures 45 and 69).

The percentage of bare ground in the 4 quadrats was determined to be 40%, 80%, 65%, and 55%. The bare ground average percentage of 60% equates to a V_{BG} subindex score of 0.29 (Figure 69).

The variable subindex scores for V_{SR}, V_{BG}, and V_{MT} are utilized to calculate the on-site assessment score modifier (Figure 64). The summary of scores for WAA3 can be seen in Figure 70.

On-site Assessment Score Modifier:

$$\left(V_{SR} + V_{BG} + V_{MT}\right)/3 \rightarrow \left(0.60 + 0.29 + 0.43\right)/3 = 0.44$$

Thus, the pre-project assessment score for WAA3 is 0.49. If the project results in a conversion of land from jurisdictional wetlands to uplands, the post-project assessment score will always be zero.

5.1.7 Alternatives analysis for WAA1, WAA2, and WAA3

After calculating scores for the three WAAs, pre-project results are compiled for comparative analysis, as shown in Table 3. Post-project scores are all zero since the result of the discharge is the conversion of land from jurisdictional wetlands to uplands. WAA1 is located in an undisturbed area, resulting in an average wetland assessment score of 0.99. WAA2 displayed some disturbance, resulting in an average score of 0.72. WAA3 is located in a disturbed landscape with pads, roads, and utility lines present, and received the lowest average score at 0.49. V_{TK} and V_{LTK} are present at WAA3; however, they have no effect on the scores because the components already score below the limiting values. Figure 71 provides an example of how assessment scores can be displayed graphically.

Figure 70. Summary of wetland assessment scores generated for WAA3 using the wetland assessment calculator.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT		
Section C: Summary of Assessment Scores		
On-Site Variable Subindex Scores		
V_{MT}	Microtopography	0.43
V_{SR}	Average species richness	0.60
V_{BG}	Average percent bare ground	0.29
V_{LDD}	Local evidence of dust deposition	No
V_{LTK}	Local evidence of thermokarst	Yes
Off-Site Variable Subindex Scores		
V_{LLD}	Local landscape disturbance	0.63
V_{SW}	Anthropogenically derived surface water	0.38
V_{IH}	Impediment to hydrology	0.50
V_{DD}	Evidence of dust	No
V_{LD}	Landscape disturbance	0.67
V_{IW}	Impediment to wildlife	0.25
V_{DR}	Distance to roadway	0.10
V_{TK}	Evidence of thermokarst	Yes
Assessment Scores		
	Habitat	***0.38***
	Hydrology	***0.53***
	Biogeochemical	***0.63***
	On-site Modifer	***0.44***
	AVERAGE SCORE	***0.49***

Table 3. Wetland assessment component scores for WAA1, WAA2, and WAA3.

Wetland Assessment Component	WAA1	WAA2	WAA3
Habitat	1.00	0.70	0.38
Hydrology	1.00	0.66	0.53
Biogeochemical cycling	1.00	0.70	0.63
On-site modifier	0.98	0.80	0.44
Average score	0.99	0.72	0.49

Figure 71. Wetland assessment component scores for WAA1, WAA2, and WAA3.

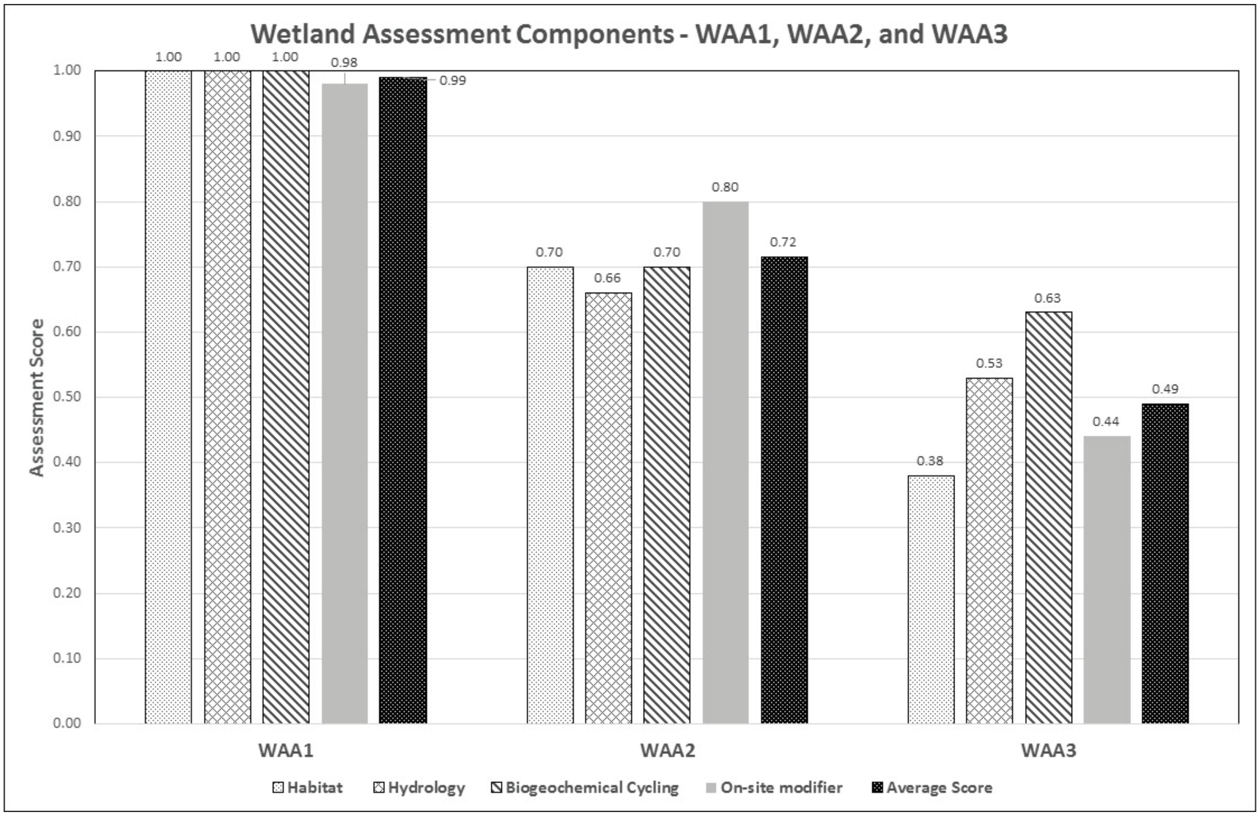


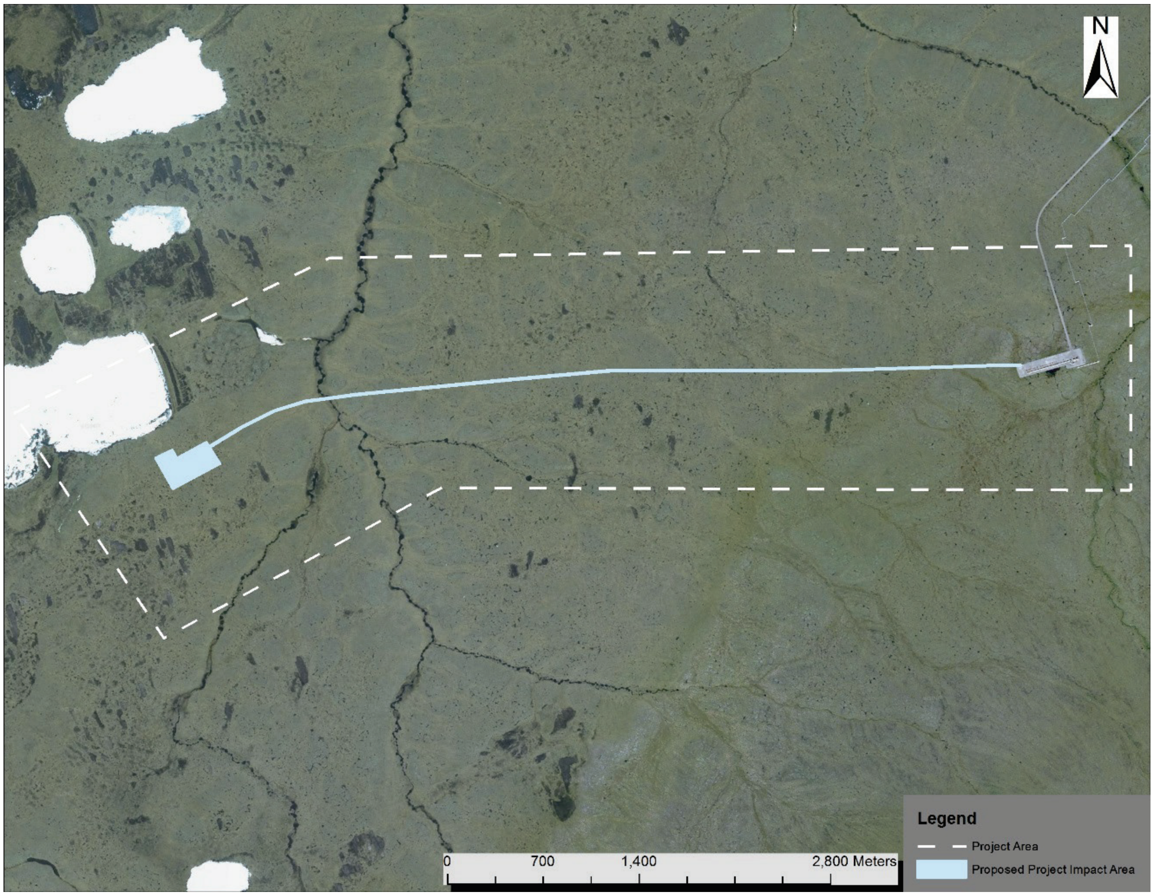
Figure 71 demonstrates that WAA1 received the highest assessment scores and likely perform wetland functions at a higher level than the other locations. WAA3 received the lowest scores and is likely the lowest functioning site. WAA2 scored in the intermediate range. As a result, the alternatives that are associated with each assessment area differ in the level of proposed impacts to wetlands within the region.

The resulting values can be incorporated into the Alaska District's CDM.

5.2 Scenario 2 – Assessment of linear project areas

The following is an example scenario that demonstrates the evaluation of a proposed development project along a linear corridor. This scenario utilizes desktop (off-site) variables only. The construction of a well-pad and access road are proposed near an existing well-pad, road, and aboveground utility line (Figure 72). The pad would occupy 8 ha and require a 5900 m by 6 m access road (3.54 ha).

Figure 72. Proposed well-pad and access road.



To effectively capture the variety of wetland resources and levels of wetland disturbances present within the project area, implement three individual WAAs (Figure 73). WAA1 is located in a flats wetland adjacent to an existing pad-site and road, representing a disturbed area. WAA2 is located in an undisturbed riverine wetland, within the footprint of the proposed access road. WAA3 is located in an undisturbed flats wetland at the site of the proposed well-pad.

5.2.1 WAA1

At the 80 m scale (Figure 74), WAA1 contains 15% V_{LLD}, 0 percent V_{SW}, 1 impeded quarter segment for $V_{IH,}$ thermokarst (V_{TK}) features, and no visible evidence of dust ("No" for V_{DD}).

At the 800 m scale (Figure 74), WAA1 contains 6% V_{LD}, 2 impeded quarter segments for V_{IW}, and the nearest roadway is located 42 m from the sample area (V_{DR}). The values for each variable assessed at the 80 m and 800 m scale are used to determine variable subindex scores via the wetland assessment calculator (Figure 75).

Figure 73. Project area with three WAAs identified.

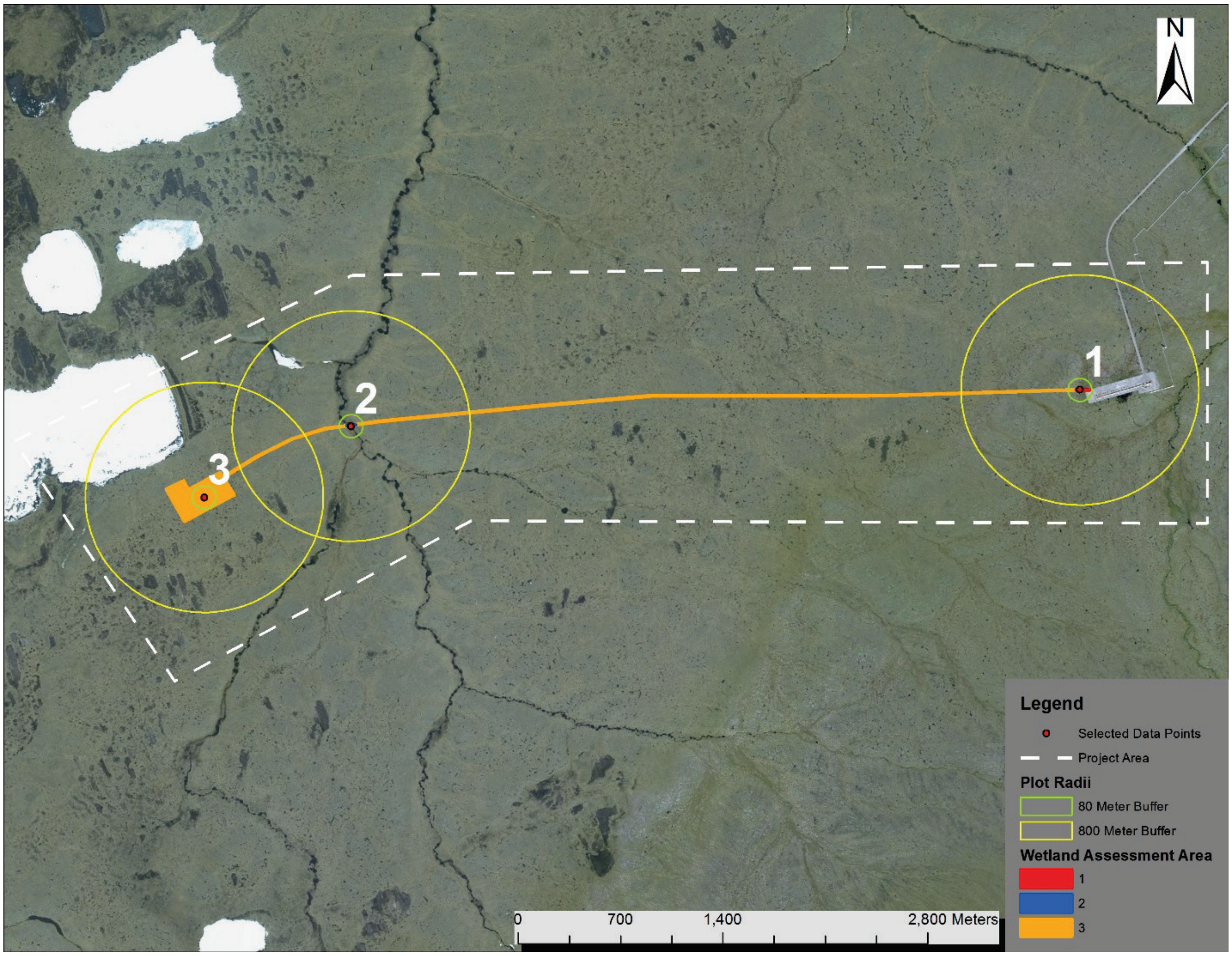


Figure 74. WAA1 located adjacent to an existing well-pad. The green shaded ¼ segment of the 80 m radius area has impediments to hydrology. The gray shaded portion of the 800 m radius area has impediments to wildlife.

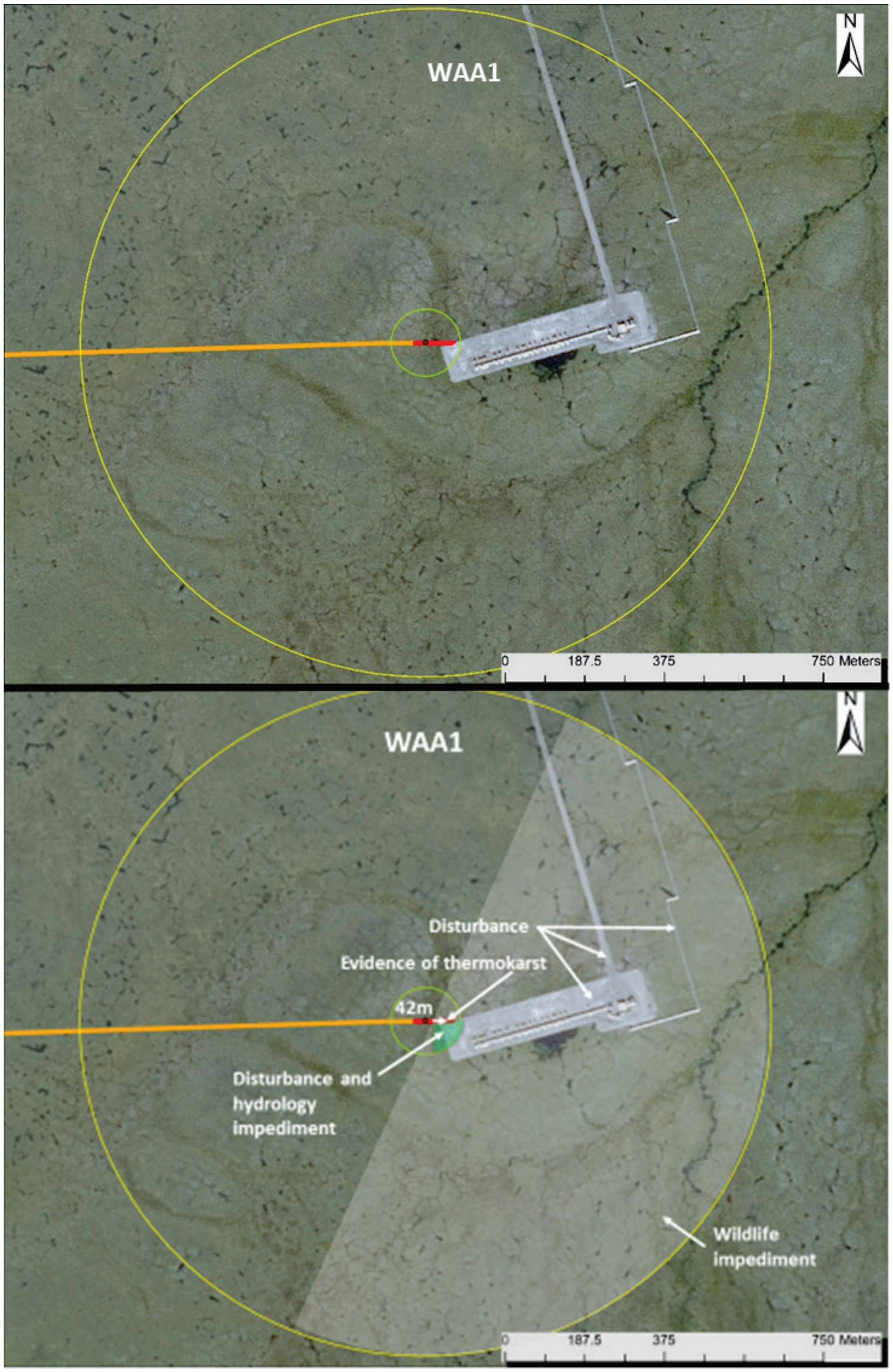


Figure 75. Example of Desktop (off-site) assessment scores for WAA1 using the wetland assessment calculator.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section C: Summary of Assessment Scores			
On-Site Variable Subindex Scores			
V_{MT}	Microtopography		
V_{SR}	Average species richness		
V_{BG}	Average percent bare ground		
V_{LDD}	Local evidence of dust deposition		
V_{LTK}	Local evidence of thermokarst		
Off-Site Variable Subindex Scores			
V_{LLD}	Local landscape disturbance	0.63	
V_{SW}	Anthropogenically derived surface water	1.00	
V_{IH}	Impediment to hydrology	0.75	
V_{DD}	Evidence of dust	No	
V_{LD}	Landscape disturbance	0.98	
V_{IW}	Impediment to wildlife	0.50	
V_{DR}	Distance to roadway	0.08	
V_{TK}	Evidence of Thermokarst	Yes	
Assessment Scores			
	Habitat	*0.44*	
	Hydrology	*0.70*	
	Biogeochemical	*0.63*	
	On-site Modifer		
	AVERAGE SCORE	*0.59*	

The variable subindex scores are used to calculate the habitat assessment score, hydrology assessment score, and the biogeochemical cycling assessment score. Because evidence of thermokarst (V_{TK}) is present, the three assessment component scores are limited to a maximum value of 0.7.

Habitat Assessment Score

The habitat assessment score is the minimum value of V_{IW} and V_{DR}, plus the sum of V_{LD} and V_{LLD}, divided by two, with the resulting quotient divided by two.

$$\left[MIN(V_{IW}, V_{DR}) + ((V_{LD} + V_{LLD})/2)\right]/2 \rightarrow \left[MIN(0.50,\ 0.08) + ((0.98 + 0.63)/2)\right]/2 = 0.44$$

Because the score is less than 0.7, the V_{TK} limit does not apply.

Hydrology Assessment Score

The hydrology assessment score is the sum of V_{IH} and V_{SW}, divided by two, multiplied by the sum of V_{LD} and V_{LLD}, divided by two, with the resulting product raised to the ½ power.

$$\left[\left(\left(V_{IH}+V_{SW}\right)/2\right) X \left(\left(V_{LD}+V_{LLD}\right)/2\right)\right]^{1/2} \rightarrow \left[\left(\left(0.75+1.00\right)/2\right) X \left(\left(0.98+0.63\right)/2\right)\right]^{1/2} = 0.81$$

Evidence of V_{TK} limits the maximum hydrology score to 0.70.

Biogeochemical Cycling Assessment Score

The biogeochemical cycling assessment score is the minimum value of V_{LD} and V_{LLD}.

$$MIN\left(V_{LD}, V_{LLD}\right) \rightarrow MIN\left(0.98, 0.63\right) = 0.63$$

Because the score in less than 0.7, the V_{TK} limit does not apply.

Average Assessment Score

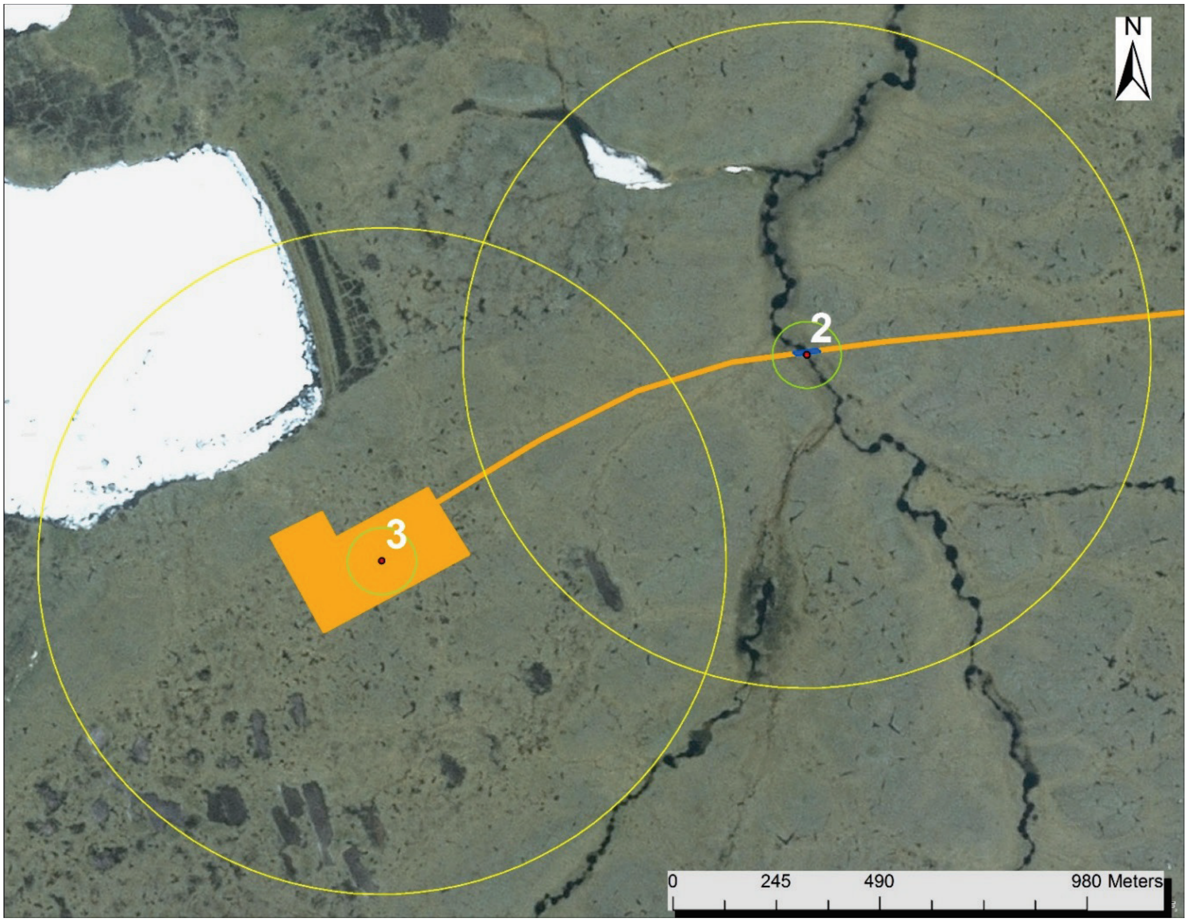
The average pre-project assessment score is the average of the habitat, hydrology, and biogeochemical cycling scores: (0.44 + 0.70 + 0.63)/3 = 0.59

If the project results in conversion of land from jurisdictional wetlands to uplands, the post-project assessment score will always be zero.

5.2.2 WAA2 and WAA3

WAA2 and WAA3 are located in undisturbed areas that represent two distinct wetland classes. As a result, each must be evaluated individually. At the 80 m scale (Figure 76), WAA2 and WAA3 each contain 0% V_{LLD}, 0% V_{SW}, 0 impeded quarter segments for V_{IH}, have no visible evidence of dust ("No" for V_{DD}), and have no visible evidence of thermokarst ("No" for V_{TK}).

Figure 76. WAA2 located in a riverine wetland, and WAA3 located in a flats wetland.



At the 800 m scale (Figure 76), WAA2 and WAA3 each contain 0% V_{LD}, 0 impeded quarter segments for V_{IW}, and are located greater than 800 m from the nearest roadway (V_{DR}). The values for each variable assessed at the 80 m and 800 m scale are used to determine variable subindex scores using the wetland assessment calculator (Figure 77).

The variable subindex scores are used to calculate the habitat assessment score, hydrology assessment score, and the biogeochemical cycling assessment score.

Habitat Assessment Score

The habitat assessment score is the minimum value of V_{IW} and V_{DR}, plus the sum of V_{LD} and V_{LLD}, divided by two, with the resulting quotient divided by two.

$$\left[MIN\left(V_{IW}, V_{DR}\right) + \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]/2 \rightarrow \left[MIN\left(1, 1\right) + \left(\left(1 + 1\right)/2\right)\right]/2 = 1.00$$

Figure 77. Example of summary of assessment scores for WAA2 generated using the wetland assessment calculator. Though it is located in a different HGM class, WAA3 would receive the same scores as WAA2.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section C: Summary of Assessment Scores			
On-Site Variable Subindex Scores			
V_{MT}	Microtopography		
V_{SR}	Average species richness		
V_{BG}	Average percent bare ground		
V_{LDD}	Local evidence of dust deposition		
V_{LTK}	Local evidence of thermokarst		
Off-Site Variable Subindex Scores			
V_{LLD}	Local landscape disturbance	1.00	
V_{SW}	Anthropogenically derived surface water	1.00	
V_{IH}	Impediment to hydrology	1.00	
V_{DD}	Evidence of dust	No	
V_{LD}	Landscape disturbance	1.00	
V_{IW}	Impediment to wildlife	1.00	
V_{DR}	Distance to roadway	1.00	
V_{TK}	Evidence of Thermokarst	No	
Assessment Scores			
	Habitat	***1.00***	
	Hydrology	***1.00***	
	Biogeochemical	***1.00***	
	On-site Modifer		
	AVERAGE SCORE	***1.00***	

Hydrology Assessment Score

The hydrology assessment score is the sum of V_{IH} and V_{SW}, divided by two, multiplied by the sum of V_{LD} and V_{LLD}, divided by two, with the resulting product raised to the ½ power.

$$\left[\left(\left(V_{IH}+V_{SW}\right)/2\right) X \left(\left(V_{LD}+V_{LLD}\right)/2\right)\right]^{1/2} \rightarrow \left[\left(\left(1+1\right)/2\right) X \left(\left(1+1\right)/2\right)\right]^{1/2} = 1.00$$

Biogeochemical Cycling Assessment Score

The biogeochemical cycling assessment score is the minimum value of V_{LD} and V_{LLD}.

$$MIN(V_{LD}, V_{LLD}) \rightarrow MIN(1, 1) = 1.00$$

Average Assessment Score

The average pre-project assessment score is the average of the habitat, hydrology, and biogeochemical cycling scores.

$$(1.0 + 1.00 + 1.00)/3 = 1.00$$

If the project results in conversion of land from jurisdictional wetlands to uplands, the post-project assessment score will always be zero.

The resulting value can be incorporated into the Alaska District's CDM.

5.3 Scenario 3 – Assessment of preservation-only mitigation

The following is an example scenario that demonstrates the evaluation of a preservation-only mitigation parcel using the pre-project (with preservation) and post-project (without preservation). This parcel has been deemed to meet the preservation criteria and has been identified as a high priority using a watershed approach (33 CFR 332.3(h)). This scenario utilizes desktop (off-site) assessment variables only.

An umbrella mitigation bank proposes to preserve a large parcel within the ACP in order to provide compensatory mitigation to offset impacts to aquatic resources from the Department of the Army permits in the service area identified in the bank's approved Instrument. The mitigation sponsor submitted a mitigation plan that offered to develop additional oil and gas infrastructure as the threat of destruction or adverse modification to the aquatic functions present on the parcel.

An evaluation of existing oil and gas projects in the watershed suggests that the construction of a 600 m x 200 m well-pad and an attendant road connecting the project to the existing road system is reasonable and likely to occur on the subject parcel. The construction of a 600 m x 200 m

(12 ha) well-pad and a 1000 m x 6 m (0.6 ha) access road were interpolated onto the subject parcel and the resulting effects of disturbance, hydrology disruption, thermokarst, and anthropogenic surface water was predicted (Figure 78).

Figure 78. Parcel boundary and projected footprint of well-pad and access road, as identified in mitigation plan.

The existing state of the parcel is considered to be undisturbed, which is best described as a flats wetland HGM class.

5.3.1 WAA1 and WAA2 pre-project assessment ($WAA1_{PRE}$ and $WAA2_{PRE}$)

The pre-project assessment is performed first, by evaluating the parcel in its "with preservation" condition, which in this case is the existing or current condition. For this step, the score for $WAA1_{PRE}$ and $WAA2_{PRE}$ will be the same since the "with preservation" state is anticipated to be the same, an undisturbed flats wetland.

At the 80 m scale (Figure 79), $WAA1_{PRE}$ and $WAA2_{PRE}$ contain 0% V_{LLD}, 0% V_{SW}, 0 impeded quarter segments for V_{IH}, and has no visible evidence of dust ("No" for V_{DD}) or thermokarst ("No" for V_{TK}).

At the 800 m scale (Figure 79), $WAA1_{PRE}$ and $WAA2_{PRE}$ contain 0% V_{LD}, 0 impeded quarter segments for V_{IW}, and the nearest roadway is located more than 800 m from the sample area (V_{DR}). The values for each variable assessed at the 80 m and 800 m scale are used to determine variable subindex scores using the wetland assessment calculator (Figure 80).

Figure 79. Location of WAA1 and WAA2 with associated data points

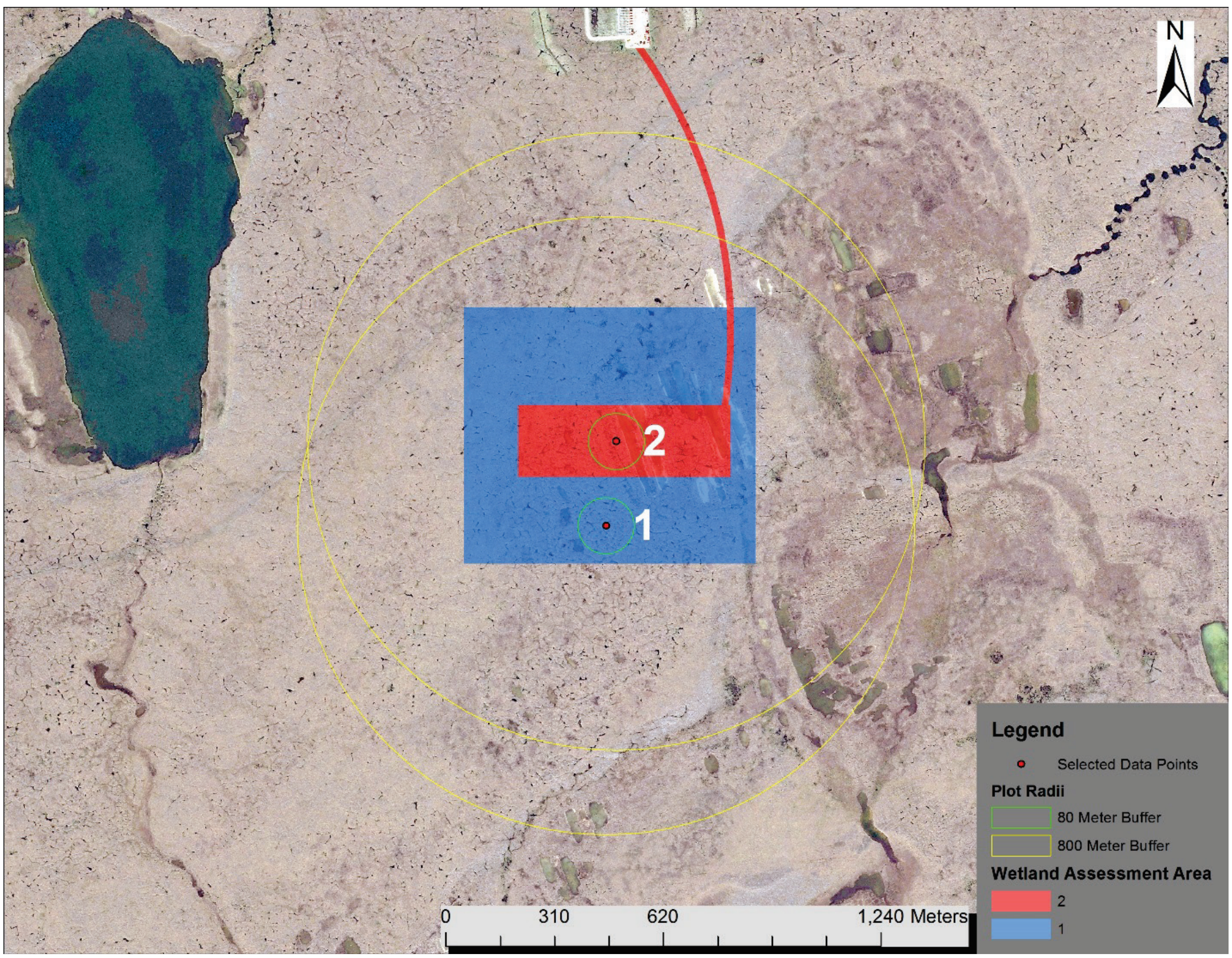


Figure 80. Example of off-site assessment scores for $WAA1_{PRE}$ using the wetland assessment calculator.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:	WAA1	Latitude/UTM Northing:	XXXX-XXXXX
Date:	8/21/2016	Longitude/UTM Easting:	XXXX-XXXXX
Impact/Mitigation	Mitigation	Pre/Post	Pre-Project
Region:	Arctic Coastal Plain	Coordinate System:	DATUM 123
HGM Class:	Flat	Imagery Source (Year):	XYZ flight 6/06/2016
Investigator(s):	John Smith, Jane Smith		

Determine values for variables 1-5 using an 80 meter radius plot.			
1	V_{LLD}	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	0
		V_{LLD} Subindex Score	***1.00***
2	V_{SW}	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	0
		V_{SW} Subindex Score	***1.00***
3	V_{IH}	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	0
		V_{IH} Subindex Score	***1.00***
4	V_{DD}	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	No
5	V_{TK}	Evidence of Thermokarst	No
Determine values for variables 6-8 using an 800 meter radius plot.			
6	V_{LD}	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	0
		V_{LD} Subindex Score	***1.00***
7	V_{IW}	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	0
		V_{IW} Subindex Score	***1.00***
8	V_{DR}	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	800
		V_{DR} Subindex Score	***1.00***
		Habitat Assessment Score	***1.00***
		Hydrology Assessment Score	***1.00***
		Biogeochemical Cycling Assessment Score	***1.00***

The variable subindex scores are used to calculate the habitat assessment score, hydrology assessment score, and the biogeochemical cycling assessment score.

Habitat Assessment Score

The habitat assessment score is the minimum value of V_{IW} and V_{DR}, plus the sum of V_{LD} and V_{LLD}, divided by two, with the resulting quotient divided by two.

$$\left[MIN\left(V_{IW}, V_{DR}\right) + \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]/2 \rightarrow \left[MIN\left(1.00, 1.00\right) + \left(\left(1.00 + 1.00\right)/2\right)\right]/2 = 1.00$$

Hydrology Assessment Score

The hydrology assessment score is the sum of V_{IH} and V_{SW}, divided by two, multiplied by the sum of V_{LD} and V_{LLD}, divided by two, with the resulting product raised to the ½ power.

$$\left[\left(\left(V_{IH} + V_{SW}\right)/2\right) X \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]^{1/2} \rightarrow \left[\left(\left(1.00 + 1.00\right)/2\right) X \left(\left(1.00 + 1.00\right)/2\right)\right]^{1/2} = 1.00$$

Biogeochemical Cycling Assessment Score

The biogeochemical cycling assessment score is the minimum value of V_{LD} and V_{LLD}.

$$MIN\left(V_{LD}, V_{LLD}\right) \rightarrow MIN\left(1.00, 1.00\right) = 1.00$$

Average Assessment Scores

The average assessment score is the average of the habitat, hydrology, and biogeochemical cycling scores: (1.00 + 1.00 + 1.00)/3 = 1.00

5.3.2 WAA1 post-project assessment ($WAA1_{POST}$)

At the 80 m scale (Figure 79), $WAA1_{POST}$ would likely contain 0% V_{LLD}, 0% V_{SW}, no impeded quarter segments for V_{IH}, and would likely demonstrate visible evidence of dust ("Yes" for V_{DD}) and thermokarst ("Yes" for V_{TK}).

At the 800 m scale (Figure 79), $WAA1_{POST}$ would likely contain 6% V_{LD}, 2 impeded quarter segments for V_{IW}, and would be located 125 m from the nearest roadway (V_{DR}). The values for each variable assessed at the 80 m and 800 m scale are used to determine variable subindex scores using the wetland assessment calculator (Figure 81).

Figure 81. Example of summary of assessment scores for WAA1POST generated using the wetland assessment calculator.

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:	WAA1	Latitude/UTM Northing:	XXXX-XXXXX
Date:	8/21/2016	Longitude/UTM Easting:	XXXX-XXXXX
Impact/Mitigation	Mitigation	Pre/Post	Post-Project
Region:	Arctic Coastal Plain	Coordinate System:	DATUM 123
HGM Class:	Flat	Imagery Source (Year):	XYZ flight 6/06/2016
Investigator(s):	John Smith, Jane Smith		

Determine values for variables 1-5 using an 80 meter radius plot.			
1	**V_{LLD}**	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	0
		V_{LLD} Subindex Score	***1.00***
2	**V_{SW}**	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	0
		V_{SW} Subindex Score	***1.00***
3	**V_{IH}**	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	0
		V_{IH} Subindex Score	***1.00***
4	**V_{DD}**	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	Yes
5	**V_{TK}**	Evidence of Thermokarst	Yes
Determine values for variables 6-8 using an 800 meter radius plot.			
6	**V_{LD}**	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	6
		V_{LD} Subindex Score	***0.98***
7	**V_{IW}**	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	2
		V_{IW} Subindex Score	***0.50***
8	**V_{DR}**	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	125
		V_{DR} Subindex Score	***0.25***
		Habitat Assessment Score	***0.62***
		Hydrology Assessment Score	***0.70***
		Biogeochemical Cycling Assessment Score	***0.70***

The variable subindex scores are used to calculate the habitat assessment score, hydrology assessment score, and the biogeochemical cycling assessment score.

Habitat Assessment Score

The habitat assessment score is the minimum value of V_{IW} and V_{DR}, plus the sum of V_{LD} and V_{LLD}, divided by two, with the resulting quotient divided by two.

$$\left[MIN\left(V_{IW},\ V_{DR}\right) + \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]/2 \rightarrow \left[MIN\left(0.50,\ 0.25\right) + \left(\left(0.98 + 1\right)/2\right)\right]/2 = 0.62$$

Because the score in less than 0.7, the V_{TK} limit does not apply.

Hydrology Assessment Score

The hydrology assessment score is the sum of V_{IH} and V_{SW}, divided by two, multiplied by the sum of V_{LD} and V_{LLD}, divided by two, with the resulting product raised to the ½ power.

$$\left[\left(\left(V_{IH} + V_{SW}\right)/2\right) X \left(\left(V_{LD} + V_{LLD}\right)/2\right)\right]^{1/2} \rightarrow \left[\left(\left(1 + 1\right)/2\right) X \left(\left(0.98 + 1\right)/2\right)\right]^{1/2} = 0.70$$

Biogeochemical Cycling Assessment Score

The biogeochemical cycling assessment score is the minimum value of V_{LD} and V_{LLD}.

$$MIN\left(V_{LD},\ V_{LLD}\right) \rightarrow MIN\left(0.98,\ 0.98\right) = 0.70$$

The variable subindex scores are used to calculate the habitat assessment score, hydrology assessment score, and the biogeochemical cycling assessment score. Because evidence of thermokarst (V_{TK}) is present, the three assessment component scores are limited to a maximum value of 0.7.

Average Assessment Score

The average assessment score is the average of the habitat, hydrology, and biogeochemical cycling scores.

$$\left(0.62 + 0.70 + 0.70\right)/3 = 0.67$$

5.3.2 WAA2 post-project assessment ($WAA2_{POST}$)

Since the project will result in the conversion of land from jurisdictional wetlands to uplands, the post-project assessment score will be zero.

The resulting values can be incorporated into the Alaska District's CDM to determine the potential amount of credits the mitigation site can generate.

6 Summary

The sections above outline information required to conduct a rapid wetland assessment within the North Slope of Alaska. This information includes information regarding wetland classification, description of the region and associated ecological resources, assessment variables and assessment equations, protocols, and scenarios to aid users in application. Additionally, a wetland assessment calculator tool has been developed as a companion to this guidebook, which provides automated calculations of all variables and assessment scores. Notably, any rapid assessment method is limited by the quality of data inputs. As a result, users should utilize the best available tools to conduct the assessment. A variety of GIS, database, and imagery tools are available for the region (Appendix A), and the best, most current information should be utilized in the assessment. Further, this assessment approach allows for users to take advantage of on-site data, when available or as directed by USACE, or to operate the assessment based upon desktop (off-site) data only due to the remote nature of the region and the short growing season.

Questions regarding the operation of the wetland assessment should be directed toward the USACE Alaska District – Regulatory Division at 907-753-2712; regpagemaster@usace.army.mil. Updates to this methodology may be considered based upon user input, evaluation of additional data, or other factors to further refine and improve rapid assessment approaches in the region.

References

Alaska Dept. of Fish and Game (ADFG). 2006. *Our wealth maintained: A strategy for conserving Alaska's diverse wildlife and fish resources*. Juneau, AK: Alaska Department of Fish and Game.

Bailey R. G. 1995. Description of the ecoregions of the United States. USDA Forest Service Miscellaneous Publication 1391. Washington, DC: U.S. Forest Service.

Berendse, F., and S. Jonasson. 1992. Nutrient use and nutrient cycling in northern ecosystems. In *Arctic ecosystems in a changing climate: An ecophysiological perspective*, eds. F. S. Chapin III, R. L. Jefferies, J. F. Reynolds, G. R. Shaver, J. S. Svoboda, and E. W. Chu, 337-356. New York, NY: Academic Press, Inc.

Berkowitz, J. F., C. V. Noble, E. A. Summers, J. R. White, and R. D. DeLaune. 2014. Investigation of biogeochemical functional proxies in headwater streams across a range of channel and catchment alterations. *Environmental Management* 53(3): 534–548.

Boelman, N. T., L. Gough, J. Wingfield, S. Goetz, A. Asmus, H. E. Chmura, J. S. Krause, J. H. Perez, S. K. Sweet, and K. C. Guay. 2015. Greater shrub dominance alters breeding habitat and food resources for migratory songbirds in Alaskan arctic tundra. *Global Change Biology* 21(4): 1508–1520.

Bormann, F. H., and G. E. Likens. 1970. The nutrient cycles of an ecosystem. *Scientific American* 223(4): 92–101.

Bridgham, S. D., C. L Ping, J. L. Richardson, and K. Updegraff. 2001. Soils of Northern Peatlands: Histosols and Gelosols. In *Wetland soils: genesis, hydrology, and classification*, eds. J. L Richardson and M. J. Vepraskas, 343–370. Boca Raton, FL: CRC Press.

Brinson, M. M. 1993. *A hydrogeomorphic classification for wetlands*. Wetlands Research Program Technical Report WRP-DE-4. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station.

Buol, S. W., R. J. Southard, R. C. Graham, and P. A. McDaniel. 2006. *Soil genesis and classification, 6th Edition*. Sussex, United Kingdom: John Wiley and Sons.

Chapin, III, F. S., N. Fetcher, K. Kielland, K. R. Everett, and A. E. Linkins. 1993. Productivity and nutrient cycling of Alaskan tundra: Enhancement by flowing soil water. *Ecology* 69: (3)693–702.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Croonquist, M. J., and R. P. Brooks. 1991. Use of avian and mammalian guilds as indicators of cumulative impacts in riparian wetland areas. *Environmental Management* 15(5): 701–714.

Davis, N. 2001. Permafrost: A guide to frozen ground in transition. Fairbanks, AK: University of Alaska Press.

Frey, K. E., and J. W. McClelland. 2009. Impacts of permafrost degradation on arctic river biogeochemistry." *Hydrological Processes* 23(1): 169–182.

Furness, R. W., and J. J. D. Greenwood. 1993. Birds as monitors of environmental change. New York, NY: Springer Science + Business Media.

Gallant, A. L., E. F. Binnian, J. M. Omernik, and M. B. Shasby. 1995. Ecoregions of Alaska. U.S. Geological Survey Professional Paper 1567. Washington, DC: United States Government Printing Office.

Giblin, A. E., K. J. Nadelhoffer, G. R. Shaver, J. A. Laundre, and A. J. McKerrow. 1991. Biogeochemical diversity along a riverside toposequence in arctic Alaska. *Ecological monographs* 61(4): 415–435.

Hammerschmidt, C. R., W. F. Fitzgerald, C. H. Lamborg, P. H. Balcom, and C.-M. Tseng. 2006. Biogeochemical cycling of methylmercury in lakes and tundra watersheds of Arctic Alaska. *Environmental Sci. Technol.* 40(4): 1204–1211.

Johnson, S. R., and D. R. Herter. 1989. The birds of the Beaufort Sea. Anchorage, AK: British Petroleum Exploration.

Jonasson, S., A. Michelsen, and I. K. Schmidt. 1999. Coupling of nutrient cycling and carbon dynamics in the Arctic, integration of soil microbial and plant processes. *Applied Soil Ecology* 11(2–3): 135–146.

Jonasson, S., and G. R. Shaver. 1999. Within-stand nutrient cycling in arctic and boreal wetlands. *Ecology* 80(7): 2139–2150.

Jorgenson, M. T., J. E. Roth, P. F. Miller, M. J. Macander, M. S. Duffy, A. F. Wells, G. V. Frost, and E. R. Pullman. 2009. An ecological land survey and landcover map of the Arctic Network. Natural Resource Technical Report NPS/ARCN/NRTR—2009/270. Fort Collins, CO: U.S. National Park Service, Natural Resource Program Center.

Kessel, B. 1979. Avian habitat classification for Alaska. *The Murrelet* 60(3): 86–94.

Liebezeit, J. R., S. J. Kendall, S. Brown, C. B. Johnson, P. Martin, T. L. McDonald, D. C. Payer C. L. Rea, B. Steever, A. M. Wildman, and S. Zack. 2009. Influence of human development and predators on nest survival of tundra birds, Arctic Coastal Plain, Alaska. *Ecological Applications* 19(6): 1628–1644.

Mack, M. C., E. A. G. Schuur, M. Syndonia Bret-Harte, G. R. Shaver, and F. S. Chapin,III. 2004. Ecosystem carbon storage in arctic tundra reduced by long-term nutrient fertilization. Nature 431(7007): 440–443.

Markon, C.J. 2001. Seven-year phenological record of the Alaskan ecoregions derived from advanced very high resolution radiometer normalized difference vegetation index data. Open-File Report 01-11. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey.

McGuire, A. D., L. G. Anderson, T. R. Christensen, S. Dallimore, L. Guo, D. J. Hayes, M. Heimann, T. D. Lorenson, R. W. Macdonald, and N. Roulet. 2009. Sensitivity of the carbon cycle in the Arctic to climate change. *Ecological Monographs* 79(4): 523–555.

McNamara, J. P., D. L. Kane, and L. D. Hinzman. 1998. An analysis of streamflow hydrology in the Kuparuk River Basin, Arctic Alaska: A nested watershed approach. *Journal of Hydrology* 206(1-2): 39–57.

Mitsch, W. J., and J. G. Gosselink. 2007. Wetlands. 4th edition. New York, NY: John Wiley & Sons.

Morrison, M. L. 1986. Bird populations as indicators of environmental change. *Current Ornithology* 3: 429–451.

Nellemann, C., I. Vistnes, P. Jordhøy, O. Strand, and A. Newton. 2003. Progressive impact of piecemeal infrastructure development on wild reindeer. *Biological Conservation* 113(2): 307–317.

Noble, C. V., E. A. Summers, and J. F. Berkowitz. 2014. *Validating the operational draft regional guidebook for the functional assessment of high-gradient ephemeral and intermittent headwater streams*. ERDC/EL TR-14-7. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Noble, C. V., and J. F. Berkowitz. 2016. Wetland soils and the hydrogeomorphic classification of wetlands. In *Wetland soils: Genesis, hydrology, landscapes, and classification,* 2nd edition, M. J. Vepraskas and C. B. Craft, 393–424. Boca Raton, FL: CRC Press.

North Slope Science Initiative (NSSI). 2013. North Slope Science Initiative (NSSI) Landcover Mapping Summary Report. Rancho Cordova, CA: Ducks Unlimited, Inc.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. *Handbook of field methods for monitoring landbirds*. General Technical Report PSW-GTR-144-Web. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Reddy, K. R., and R. D. DeLaune. 2008. Biogeochemistry of wetlands: Science and applications. Boca Raton, FL: CRC press.

Roulet, N. T., and M-K Woo. 1986. Hydrology of a wetland in the continuous permafrost region. *Journal of Hydrology* 89(1–2): 73–91

Rovansek, R. J., L. D. Hinzman, and D. L. Kane. 1996. Hydrology of a tundra wetland complex on the Alaskan Arctic Coastal Plain, USA. *Arctic and Alpine Research* 28(3): 311–317.

Schuur, E. A. G., J. Bockheim, J. G. Canadell, E. Euskirchen, C. B. Field, S. V. Goryachkin, S. Hagemann, P. Kuhry, P. M. Lafleur, H. Lee, G. Mazhitova, F. E. Nelson, A. Rinke, V. E. Romanovsky, N. Shiklomanov, C. Tarnocai, S. Venevsky, J. G. Vogel, and S. A. Zimov. 2008. Vulnerability of permafrost carbon to climate change: implications for the global carbon cycle. *BioScience* 58(8): 701–714.

Shafer, D., and D. J. Yozzo. 1998. *National guidebook for application of hydrogeomorphic assessment to tidal fringe wetlands*. Wetlands Research Program TR WRP-DE-16. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station.

Shaver, G. R., and F. S. Chapin, III. 1991. Production: biomass relationships and element cycling in contrasting arctic vegetation types." *Ecological Monographs* 61(1): 1–31.

Shaver, G. R., W. D. Billings, F. Chapin, III, A. E. Giblin, K. J. Nadelhoffer, W. C. Oechel, and E. B. Rastetter. 1992. Global change and the carbon balance of arctic ecosystems. *BioScience* 42(6): 433–441.

Smith, R. D., A. Ammann, C. Bartoldus, and M. M. Brinson. 1995. *An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices*. Wetlands Research Program Technical Report WRP-DE-9. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station.

Smith, R. D, C. V. Noble, and J. F. Berkowitz. 2013. *Hydrogeomorphic (HGM) approach to assessing wetland functions: Guidelines for developing guidebooks (version 2)*. ERDC/EL TR-13-11. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Sullivan, P. F., S. J. T. Arens, R. A. Chimner, and J. M. Welker. 2008. Temperature and microtopography interact to control carbon cycling in a high arctic fen. *Ecosystems* 11(1): 61–76.

Summers, E., C. V. Noble, and J. F. Berkowitz. 2017. *Operational draft regional guidebook for the functional assessment of high-gradient headwater streams and low-gradient perennial streams in Appalachia*. ERDC/EL TR-17-1. Vicksburg, MS: U. S Army Engineer Research and Development Center.

Summers, E., J. F. Berkowitz, C. V. Noble, and F. Spilker. 2015. Evaluating a rapid assessment method using salamander community metrics. *Wetland Science and Practice* 32(4): 9–14.

U.S. Army Corps of Engineers. 2007. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Alaska Region (Version 2.0)*. ERDC/EL TR-07-24. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. Washington, D.C.: U.S. Department of Agriculture.

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). 2004. Land resource regions and major land resource areas of Alaska. Palmer, AK: United States Department of Agriculture-NRCS.

U.S. Department of the Interior - Bureau of Land Management (USDOI-BLM). 2012. National Petroleum Reserve-Alaska final Integrated Activity Plan/ Environmental Impact Statement. Anchorage, AK: U.S. Department of the Interior, Bureau of Land Management.

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. Gen. Tech. Rep. PNW-GTR-286. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Wahrhaftig, C. 1965. Physiographic divisions of Alaska. Geological Survey Professional Paper 482. Washington, DC: U.S. Department of the Interior.

Walker, D. A., and K. R. Everett. 1987. Road dust and its environmental impact on Alaskan taiga and tundra. *Arctic and Alpine Research* 19(4): 479–489.

Woo, M-K., and K. L. Young. 2006. High Arctic wetlands: Their occurrence, hydrological characteristics and sustainability. *Journal of Hydrology* 320(3–4): 432–450.

Woo, M-K., and T. C. Winter. 1993. The role of permafrost and seasonal frost in the hydrology of northern wetlands in North America. *Journal of hydrology* 141(1–4): 5–31.

Appendix A: Resources for Wetland Classification, Assisting in Site Characterization, and Conducting Off-Site Analysis of Wetlands within the North Slope Region

A hydrogeomorphic classification for wetlands (Brinson 1993).
http://www.dtic.mil/docs/citations/ADA270053

Hydrogeomorphic (HGM) Approach to assessing wetland functions: Guidelines for developing guidebooks (Version 2) (Smith et al. 2013).
http://www.dtic.mil/docs/citations/ADA583904

North Slope Science Catalog- North Slope Science Initiative (NSSI 2013)
http://catalog.northslope.org/catalog

Over 80 datasets available for North Slope Alaska, including:

- Digital Elevation Models (DEMs)
- Permafrost and ground-ice characterization
- NSSI Landcover (30 m resolution)
- National Hydrology Datasets
- Climate Datasets
- LANDFIRE Existing Vegetation Type Maps
- Snow cover and Ice Analyses (freeze and thaw depths)
- Unified Ecoregions of Alaska

Geographical Information Network of Alaska—GINA http://gina.alaska.edu/data

A host of GIS data layers including, but not limited to:

- Advanced Very High Resolution Radiometer (AVHRR)
- MODIS and Landsat satellite images
- Digital Elevation Models (DEM's)

Toolik Field Station Spatial Data. http://toolik.alaska.edu/gis/data/

The Toolik Field station develops, archives, and distributes spatial data applicable for research in the Toolik Region. The Toolik Field Station archives an assortment of GIS and remote sensing datasets including:

- Digital Elevation Models (DEMs) (high-resolution for selected localities)
- Landscape Disturbance
- Assortment of Satellite and Aerial imagery
- Landscape Hydrology

Alaska DNR—Division of Oil and Gas: GIS Data Downloads
http://dog.dnr.alaska.gov/GIS/GISDataFiles.htm

Oil and gas GIS data including leases, units, and participating areas in Alaska.

USGS (formerly available via Alaska Geospatial Data Clearinghouse (AGDC))

Available at http://catalog.data.gov/dataset and https://www.sciencebase.gov/catalog

Example datasets include:

- Land Surface Characterization for Alaska and Arctic Regions
- Water Resources of Alaska GIS Data
- Digital Elevation Models
- Statewide Geologic Maps for Alaska

Appendix B: Data Form

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section A: Desk Top (Offsite) Data			
Site Name/Location:		Latitude/UTM Northing:	
Date:		Longitude/UTM Easting:	
Impact/Mitigation:		Pre/Post:	
Region:		Coordinate System:	
HGM Class:		Imagery Source (Year):	
Investigator(s):			

Determine values for variables 1-5 using an 80 meter radius plot.			
1	V_{LLD}	Local Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	
		V_{LLD} Subindex Score	
2	V_{SW}	Anthropogenically Derived Surface Water - percent of the plot (0 - 100) occupied by surface water derived from human activities, including thermokarst if directly associated, and conspicuously linked.	
		V_{SW} Subindex Score	
3	V_{IH}	Impediment to Hydrology - number of quarter segments (0 - 4) assignable in any direction that have hydrologic impediments.	
		V_{IH} Subindex Score	
4	V_{DD}	Evidence of Dust - accumulation of sediment on vegetation, appearing as areas of discoloration.	
5	V_{TK}	Evidence of Thermokarst	
Determine values for variables 6-8 using an 800 meter radius plot.			
6	V_{LD}	Landscape Disturbance - percent of the plot (0 - 100) occupied by anthropogenic disturbance and/or man-made features.	
		V_{LD} Subindex Score	
7	V_{IW}	Impediment to Wildlife - number of quarter segments (0 - 4) assignable in any direction with impediments to the free movement of wildlife.	
		V_{IW} Subindex Score	
8	V_{DR}	Distance to Roadway - minimum distance in meters (0 - 800) to a roadway of any size, class, or condition.	
		V_{DR} Subindex Score	
		Habitat Assessment Score	
		Hydrology Assessment Score	
		Biogeochemical Cycling Assessment Score	

Remarks

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT								
Section B: Onsite Data Collection								
Site Name/Location:					Latitude/UTM Northing:			
Sampling Date:					Longitude/UTM Easting:			
Region:					Coordinate System:			
HGM Class:					Dominant Vegetation:			
Field Team:								
Determine values for the following variables:								
1 V_{LDD}	Dust presence on vegetation within assessment area?							
2 V_{LTK}	Thermokarst features within assessment area?							
3 V_{MT}	Microtopography Sampling using two 30m transects situated in each cardinal direction from established plot center. Establish a level line above vegetation and record distance to ground level at 1m intervals.							
Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)		Distance	Depth to Ground (cm)	Distance	Depth to Ground (cm)
1		16			1		16	
2		17			2		17	
3		18			3		18	
4		19			4		19	
5		20			5		20	
6		21			6		21	
7		22			7		22	
8		23			8		23	
9		24			9		24	
10		25			10		25	
11		26			11		26	
12		27			12		27	
13		28			13		28	
14		29			14		29	
15		30			15		30	
Sum of Microtopography Variability:					*V_{MT} Subindex Score:*			
4 V_{SR}	**Species Richness** tally for vascular plants using 4 randomly assigned 1m^2 quadrats within each quadrant created from transect lines:							
Quadrat 1:					Quadrat 3:			
Quadrat 2:					Quadrat 4:			
Average Species Richness:					*V_{SR} Subindex Score:*			
5 V_{BG}	**Bare Ground** percent cover (0-100%) estimates using four randomly assigned 1m^2 quadrats within each transect quadrant:							
Quadrat 1:					Quadrat 3:			
Quadrat 2:					Quadrat 4:			
Average Bare Ground Percentage					*V_{BG} Subindex Score:*			
Site Notes/Remarks:								
On-Site Assessment Score								

ALASKA NORTH SLOPE REGION RAPID WETLAND ASSESSMENT			
Section C: Summary of Assessment Scores			
On-Site Variable Subindex Scores			
V_{MT}	Microtopography		
V_{SR}	Average species richness		
V_{BG}	Average percent bare ground		
V_{LDD}	Local evidence of dust deposition		
V_{LTK}	Local evidence of thermokarst		
Off-Site Variable Subindex Scores			
V_{LLD}	Local landscape disturbance		
V_{SW}	Anthropogenically derived surface water		
V_{IH}	Impediment to hydrology		
V_{DD}	Evidence of dust		
V_{LD}	Landscape disturbance		
V_{IW}	Impediment to wildlife		
V_{DR}	Distance to roadway		
V_{TK}	Evidence of thermokarst		
Assessment Scores			
	Habitat		
	Hydrology		
	Biogeochemical		
	On-site Modifer		
	AVERAGE SCORE		

REPORT DOCUMENTATION PAGE						*Form Approved OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*
August 2017

2. REPORT TYPE
Technical Report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Operational Draft Regional Guidebook for the Rapid Assessment of Wetlands in the North Slope Region of Alaska

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Jacob F. Berkowitz, Nathan R. Beane, Kevin Philley, and Matt Ferguson

5d. PROJECT NUMBER
A1210-North Slope Alaska

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center
Environmental Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/EL TR-17-14

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSOR/MONITOR'S ACRONYM(S)
WRAP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This guidebook describes a rapid approach to assessing wetlands within the Arctic Foothills and Arctic Coastal Plain (North Slope) region of Alaska. This report utilized established approaches to (1) characterize regional wetlands, (2) provide the rationale used to determine assessment scores, (3) describe assessment variables utilized, (4) outline the developed assessment equations, and (5) provide a step-by-step protocol for applying results. The region’s remote nature and short growing season limits the time period during which on-site data can be collected. As a result, the developed method allows for a tiered approach utilizing (1) an assessment based upon off-site data (remotely sensed or desktop resources) only or (2) an assessment using a combination of on-site (field data collection) and off-site data collection. On-site data collection may be required at the discretion of USACE. Several scenarios are presented to aid users in conducting the rapid wetland assessment.

15. SUBJECT TERMS

Assessment	North Slope Region
Biogeochemical cycling	Rapid wetland assessment
Habitat	

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Sally Stroupe
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	127	19b. TELEPHONE NUMBER *(Include area code)* (601) 634-3622